

THE THIRD GENERATION COMPUTER

Software Issues

*Information Input, Access,
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Management Information Systems



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135 WEST 50 STREET • NEW YORK, NEW YORK 10020

THE STATE OF THE ART AND FUTURE TRENDS •

ARTHUR J. WHITMORE

THE TERM "SOFTWARE" DOES NOT MEAN THE same thing to everyone who uses it, and a discussion of software must begin with choosing one of three commonly used definitions:

1. Software comprises all computer programs written and supported by the equipment supplier and made available to the equipment users.
2. Software covers all computer programs written by the equipment supplier and those written by the users.
3. Software includes all but the physical hardware; that is, software includes computer programs, supplier equipment maintenance, programming and operations schools, manuals, and so on.

My discussion will primarily be concerned with supplier-generated software.

An all-encompassing classification and detailed discussion of the software field is beyond the scope of this article; however, in order to provide a framework on which to base further discussions, I have chosen four classifications of software and will discuss within these classifications only the general software characteristics. The four classifications are: (1) programming languages; (2) operating systems (monitors, executive systems, master control programs, and so forth); (3) special-purpose software packages; and (4) application programming.

Programming languages. In discussing programming languages I will consider levels or hierarchies of languages rather than discuss particular languages. The levels or hierarchies may be classified as: (1) basic, or actual; (2) symbolic; (3) interpretive; and (4) higher-level.

Actual, or basic programming languages very closely approximate the equipment internal operation format. Programmers using these languages must be quite familiar with the particular

equipment used and must consider such things as memory addressing schemes, accumulator or index register addressing, register size, shift operations, position in word of algebraic sign, hardware addresses, and the like. Writing and debugging programs in actual or basic language are laborious, time-consuming, and error-prone tasks; and they represent a bottleneck in implementing mechanized systems. In the early days of the industry, users accepting equipment had little alternative but to use these programming languages as the supplier usually furnished little more than the hardware. One would not expect users, at today's stage of industry development, to be forced to write in actual machine language; unfortunately, this is still done.

Symbolic programming languages were developed to ease the programming bottleneck. In using these programming languages, the programmer refers to data and instruction locations by symbolic names rather than actual memory addresses, and he uses mnemonics rather than numerics in specifying operation codes—for example, the mnemonic symbol "MVE" rather than "09." These languages required an interface program which converts the program from symbolic form to actual machine language. The interface programs, called assemblers, were usually written by the suppliers and furnished with the equipment, although many symbolic languages and assemblers were designed by users. A recent survey indicated that well over 1,000 symbolic and actual programming languages are in existence. The capability of symbolic languages was increased through the addition of macrofacilities (a single program

ARTHUR J. WHITMORE is Consultant—Business Systems, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

statement which can generate many machine steps) and the development of a library of generalized subroutines such as input-output routines with error checking. The suppliers, as well as furnishing assemblers, also furnished utility programs (card-to-tape, tape-to-printer, and the like) and sort packages, thus easing some of the user's programming burden.

Interpretive programming languages enjoyed a somewhat brief period of popularity. They were designed to permit nonprogrammers such as engineers and scientists to write computer programs. Their use expanded programmer productivity because of the macrocapabilities inherent in such languages. The languages usually consisted of a program base of multiple subroutines, written in machine language, which were parameterized from the programmer's statement operands. Each programmer statement was usually interpreted at execution time by a routine which determined the type of operation and then passed the parameters to the appropriate base subroutines. These systems were quite powerful but had disadvantages such as slow execution time resulting from the amount of time required for statement interpretation.

Higher-level programming languages such as COBOL, FORTRAN, and ALGOL were designed to further increase programmer productivity by permitting programs to be written in a language that closely approximates the programmer's natural language; that is, one writes mathematical expressions in ALGOL and FORTRAN in a manner similar to his normal means of expressing them, and English words and phrases are used—although in a highly stylized form—in writing programs in COBOL. Further, these languages are relatively compatible across machine lines. There are now more than 50 FORTRAN compilers (a compiler is the interface program between the program written in a higher-level language and the machine-language equivalent) and a similar number of COBOL compilers. Of course, "compatibility" as used here does not imply that a COBOL program written for one computer can be run on another with no changes; however, the conversion effort is considerably less than that involved in completely reprogramming from one symbolic language to another.

Languages such as COBOL, FORTRAN, and ALGOL are referred to as procedure-oriented languages because they are used to describe the procedures necessary to effect a problem solution. Some effort is being expended on the development of problem-oriented languages in which the problem is defined and the solution procedure is automatically generated; however, this effort is not nearly as great as it should be and results to date are disappointing.

Operating systems. Operating systems were designed to improve the operating effectiveness of computer installations; their chief advantage is the relatively nonstop operation they afford. These systems range in size and complexity from a few hundred words of memory for simple job-stacking to thousands of words for on-line real-time operation. Although considered a luxury by some users of small computers, operating systems have become an absolute necessity on newer equipment, particularly that equipment with multiprogramming capability. Multiprogramming refers to the mode of operation in which a computer with a single processor is capable of executing more than a single program at one time, as opposed to the serial mode of operation in which one program must be completed before another program can be begun.

Operating systems have four major components: scheduling function; control function; loader function; and compilers, assemblers, sorts, and utility routines. Each of these components is described below in outline form.

1. Scheduling function.

- a. Develop table of jobs to be processed (including job hardware requirements), and select jobs to be run based on priority and job hardware requirements.
- b. Allocate memory and peripheral units to jobs at time of execution.
- c. Maintain job table, purging jobs completed and adding jobs as required (includes reassignment in dynamic scheduling systems).
- d. Attempt optimum use of peripheral units by scheduling optimum job mix (for example, an input-output-bound job and a calculation-bound job).

2. Control function.

- a. Control all input-output operations.
 - b. Process all interrupts (store registers; determine type of interrupt; and take appropriate action).
 - c. Timing (develop log of job time for job accounting; maintain CPU and peripheral unit time; control individual program execution based on predetermined time limits).
 - d. Perform job-change duties (close out completed job; request unloading of tapes to be saved; release units for assignment to next job; log in new job).
 - e. Communicate with operator.
 - f. Call in needed portions of nonresident control systems.
3. Loader function.
 - a. Assign absolute memory addresses to object programs in relocatable code.
 - b. Provide facility for program changes when loading.
 - c. Control program overlays.
 4. Compilers, assemblers, sorts, and utility routines. These facilities must be called by and controlled by the operating system with no distinction between these and other installation programs.

Special-purpose software packages. Equipment suppliers have spent a good deal of time and money in building special-purpose software packages such as linear programming packages, information retrieval and data management systems, simulators (GPSS, SIMSCRIPT, and others), and PERT Time and Cost Systems. One Westinghouse Electric division was able to pick up a linear programming package to be used in our optimum steel-slitting program, thus saving the cost of one to two man-years of effort that would have been required to write the program and also permitting the implementation of the system a year early.

To determine the total cost of such special-purpose packages, the number and type of such packages available, and the savings to users is an impossibility. There is a surprising lack of available industry information. An effort should be made by industry to make available information such as number and types of people in the industry; what equipment is installed and where

it is installed; what use is being made of the equipment; and what is planned.

Application programming. Application programs are sets of programs which are developed by equipment suppliers and designed for a specific function in a given industry. All equipment suppliers have developed libraries of application programs. Some examples are the Financial Model system of RCA used to generate corporate balance sheets; IBM's MOS system used in manufacturing; the Demand Deposit Accounting system developed by General Electric for commercial banks; and others such as production line balancing, sales forecasting, and customer accounting for gas and electric utilities. Usually these application packages, because they are general in nature and designed for an industry rather than a particular user, require some modification to adapt their use to specific needs. However, the modification is slight compared with the effort required to write the original system.

To appreciate the scope of this area we might consider one equipment supplier's program library. IBM's computer library headquarters expects to distribute more than 400,000 computer programs this year. This involves more than 2,500 different programs, 300 million punched cards, 100,000 reels of magnetic tape, and 60 million pages of documentation.

ROLE OF SOFTWARE IN EQUIPMENT NEGOTIATIONS

Any user who has experienced a change of computing equipment can appreciate the difficulty of justifying program conversion cost. At more than one of Westinghouse Electric's locations this has amounted to more than \$.5 million and a year and a half of effort. One such conversion effort can very dramatically point out the cost of writing computer programs in assembly language and the value of using higher-level programming languages. Many companies have developed corporate policies regarding the use of software. At Westinghouse, we have established policies covering the use of COBOL, FORTRAN, and ALGOL which state in effect: "Within good economic practices, all data processing programs will be written in COBOL

and all engineering-scientific programs written in ALGOL or FORTRAN. Further, Westinghouse will not consider equipment for which these compilers are not available."

Many other companies have developed similar policies. Westinghouse has realized considerable benefit from implementation of this policy, and I would like to comment on the role this has played in equipment conversion. At one of our locations, a conversion has recently been completed at a cost of approximately \$.75 million and one and one-half years of elapsed time. The program load written in symbolic language was converted to COBOL and ALGOL, and this location feels that a second conversion will cost less than one-sixth the cost of the first because of the use of higher-level programming languages.

Productivity statistics also prove interesting: An industry figure often quoted is two debugged machine instructions per hour per man (including all analysis and design) when using assembly languages. One of our installations involved in a conversion effort estimated it could realize 60 per day per man using COBOL, but it actually accomplished only 40 per day per man because of extensive resystemizing. A smaller installation, using COBOL as a conversion tool, realized 180 debugged machine instructions per day per man; however, no major resystemizing was done, although a change was made from a disc system to a tape system. This location did not have the complex systems that the first had. A third location, in soliciting bids on replacement gear, found that one supplier was willing to undertake the full conversion effort simply because this location's programs were in FORTRAN and COBOL.

The use of higher-level programming languages has considerable economic significance when one considers that the equipment cost per unit of computation has decreased by a factor of two every thirty months. At the same time, however, the support effort (analysts, programmers, operations, and so forth) is constantly increasing in cost. It is essential that productivity in this area be increased, and the use of higher-level programming languages is one means of doing it. The shortage of analysts and pro-

grammers is also a factor necessitating increased productivity. There are currently between 200,000 and 300,000 analyst-programmers in the field; however, by 1970 there will be a need for 600,000.

Equipment users have begun including software specifications and acceptance tests in equipment contracts, and penalty clauses related to software are now news items. A \$100-per-day penalty related to software doesn't necessarily compensate the user for losses incurred because of late software delivery or inadequate software; however, it does cause the equipment supplier to be more conscious of software development schedules. A number of users have developed bench-mark programs and entire systems that are being used as acceptance criteria. This practice should be accepted and expanded by all equipment suppliers. If a supplier states that his software and hardware are capable of meeting certain criteria, there is no reason for his refusing to prove it.

THE STATE OF THE ART

At this point I would like to offer a few comments regarding the state of the art. I feel that we have fallen at least two years behind in the development of software, primarily because of a lack of communication between those responsible for such development and those who use the software. I am continually amazed at the incredibly poor job the equipment suppliers have been doing in the software area. Can you imagine an equipment supplier delivering a new line of gear with multiprogramming capabilities and then delaying for more than a year the software necessary to make proper use of the gear? One might have expected this in the early days of the industry but certainly not today—yet this is still happening.

In dealing with supplier's software groups I have repeatedly come into contact with the attitude that the supplier knows better than the user what is good for the user—that is, the old "General Bullmoose" attitude. For example, one supplier decided to design his business language compiler as he had designed his FORTRAN compiler. The FORTRAN compiler was de-

signed to compile rapidly but generated poor object code, primarily because FORTRAN programs were compiled often but run productively only infrequently. As a result, the business language compiler compiled rapidly but the object code generated was impossible. This supplier apparently didn't take into account the difference between an infrequently run FORTRAN program and a business program which is run day in and day out. Any of the supplier's users could have set him straight. This supplier is now undergoing a very costly redesign effort. I have little sympathy when he complains of the high cost of software.

Another supplier furnished his users with a business language compiler that compiled at the speed of four source cards per minute. Many of our programs are 2,000 source cards in size, and some are as large as 6,000 source cards. We couldn't possibly use such a slow compiler. On examining the object code generated by this compiler we found it was so poor as to make the compiler inadequate regardless of its speed. This supplier is currently rewriting the compiler at considerable expense and is advertising that the new compiler will represent a 100-to-1 improvement. In other words, a product was released on the market that is so poor that an improvement of 100-to-1 can be accomplished simply by redesigning the product as it should have been in the first place. One wonders whether the supplier's top management is aware of what their software groups are doing, for there appears to be a surprising lack of concern.

In using one supplier's sort package we discovered that it frequently grabbed files that weren't involved in the sort and sorted them right along with the others. A program might begin with 4,000 records to be sorted and end up with 15,000 sorted records. The problem was readily located, and the solution appeared to be extremely simple: The sort, in using intermediate scratch tapes, labels these tapes in order to pass them on to successive phases of the sort. Unfortunately, should a scratch tape used by an earlier sort be loaded while a sort was running, it was automatically included in the sort. The solution involved making labels unique by adding a time field consisting of day, hour, minute,

second, and hundredth of a second. This supplier's quality assurance department could have profited from communication with a user and should have tested the sort package in a user environment.

The software system furnished by another supplier doesn't perform longitudinal parity checks; as a result, master files created in one program could not be read in another program. In discussing with the director of this software group new features we assumed would be incorporated in a software system, we were told that published specifications were not yet available. We brought to his attention the fact that for over a year he had not bothered to furnish a representative to the committee developing these specifications and that, had he done so, he would be well aware of the specification content. This supplier is far along in developing a software package that will meet with user dissatisfaction.

At some of our locations we have been operating in multiprogramming mode for more than 18 months. Yet, when discussing with suppliers the software support necessary for multiprogramming, one gets the impression that they feel the only way to multiprogram is to move two machines into the same room back-to-back.

There are many other examples of operating systems that don't operate or are nonexistent, sorts that don't sort, and so on. Poorly designed and inadequate software and late delivery of software have cost Westinghouse Electric many thousands of dollars in delayed implementation of cost-reducing systems. Many of the problems in software can be attributed to a lack of communication between supplier and user.

I don't mean to imply that the fault is entirely that of the suppliers, for the users are not blameless. Too many users have abrogated their responsibilities to their companies by being indifferent to this very real problem area and by refusing to acquire the necessary level of familiarity with software. There are managers of computer installations who delegate to a programmer the responsibility for selecting the software systems and programming languages to be used. Software problems cannot be solved until managers who have either direct or indirect responsibility for computer installations are aware of:

- The one-, three-, and five-year plans developed for the installation and whether or not these objectives are being met.
- When the next equipment conversion will take place and what it will cost.
- What software systems and languages are now used.
- Whether any economic analysis of software has been accomplished—that is, what role will software play in the next conversion?
- What the computer justification document contains.

How many equipment users are active in computer users' groups? The tendency to hold users' meetings in Las Vegas, Miami, San Francisco, New Orleans, and so on has resulted in a good deal of boondoggling; however, users who are concerned with improving the current situation can do so by actively supporting and contributing to their equipment users' groups.

IMPROVING THE SOFTWARE SITUATION

The current situation can be improved by concentrated effort in four areas: education, planning, communication, and participation.

Education. Westinghouse is concerned with developing the necessary levels of competence and knowledge of its employees who are involved in the computing field. The company has developed courses and seminars that are given to all levels of management and some non-management personnel. A six-day computer concepts course is given to top management at the vice president and division manager level. These people have usually been exposed to marketing, engineering, manufacturing, accounting, and like functions; but very few have experience in the computing field. This course has been designed to assist in providing this education. In the computer concepts course the attendees learn of the use of computers at Westinghouse and outside Westinghouse, and they write programs using FORTRAN and ALGOL. These programs are not of the "bouncing ball" or "interest on \$24 deposited in 1810" types; rather they comprise a system involving sales forecasting, production requirements based on the sales fore-

cast, material explosion of production requirements, and an ordering program based on parts ordering criteria. The attendees are shown that this system is part of an integrated system in production at one of our installations. The course has been quite effective and will be continued as required.

Our education program also involves seminars offered to managers, supervisors, and non-management personnel in order to keep them abreast of the field. Too often managers of computing installations rate equipment solely on the basis of internal speeds. For example, the through-put capabilities of two of our locations—one with gear renting for \$30,000 a month and the other with gear renting for \$85,000 a month—have been analyzed; in many cases the through-put of the more expensive equipment (which is also four times as fast internally) can be equalled on the less expensive equipment. Software plays a big role in this through-put capability. It is this type of information that we want to make available to all our divisions.

Education is also needed in equipment suppliers' ranks. These people need education in how their equipment is used. Many of the specific problems I cited above could have been avoided if the software had been designed with a real-life operating environment in mind.

Planning. Equipment users have been lax in planning for equipment acquisition. Justification documents should be developed including one-, three-, and five-year guidelines and should be used to determine whether these are met by the installation. Software should play a large role in equipment acquisition planning. An economic analysis of the use of specific software systems and languages should be done in relation to current operations and future needs. Users should plan now for the next conversion and understand that software can considerably affect the conversion to new equipment. Users should also plan for alternate gear in the event of late delivery of software or hardware. Plans should be made to effect a line of communication with suppliers in order for both user and supplier to be more aware of the problems each faces.

Communication and participation. Com-

munication media exist today by which users and suppliers can assist each other in furthering the state of the art; however, they require adequate participation to be effective. Equipment users' groups such as SHARE, GUIDE, and CUBE are an excellent means of exchanging information with other users, informing the supplier of needs, and sharing experience.

Software symposiums, such as the recent SHARE/JUG sponsored seminar, also furnish a means of user-supplier communication. Unfortunately, there apparently are no plans to hold a follow-up session. A few good ideas were expressed at this seminar that seemed worthy of continuation.

The American Standards Association (ASA) provides still another manner in which those in the industry can communicate, but here again determined participation by competent personnel is required. The ASA is active in developing industry standards which will help users and suppliers alike, if only by permitting the suppliers to devote more effort to true research and development efforts. Recent Government action regarding the ASCII (American Standard Code for Information Interchange) has caused some concern, and many are unhappy that the Government has decided to enter the standards activity in so determined a manner. The attitude, "We will set standards if standards are not forthcoming," is unsettling. In any event, users and suppliers alike should be concerned enough about the development of standards to actively support this effort.

In discussing the four areas in which I believe a determined effort can improve the state of the art, I have neglected the problem of finding good people—that is, developing adequate testing devices, holding talented employees through advancement opportunities, and the like. This is an area that should be of great

concern to users and suppliers, yet little has been done to date.

In closing with a few predictions regarding software, I am reminded of the Danish proverb that states, "Prediction is difficult, particularly when it pertains to the future."

1. Users and suppliers will work more closely together in advancing the state of the art.
2. The growth of software firms will accelerate as equipment suppliers rely more heavily on outside assistance. (Of the 3,500 people involved in IBM's software development, over 10 percent are from software firms.)
3. The use of software firms may well permit marketing hardware independently of software by more clearly separating the costs of the two.
4. Software specifications will be developed by industry-sponsored, independent groups rather than by software supplier groups. This idea was offered at the SHARE/JUG symposium and should evoke industry interest.
5. Industry standards will be developed at an increasing rate and will materially further the state of the art.
6. There will be an increased use of higher-level languages such as COBOL, FORTRAN, and ALGOL in this country and abroad; and the attempt to develop one all-purpose language will prove to be a failure.
7. Operating systems will increase in use—and also in size and cost both to the user and the supplier.
8. Efforts to develop problem-oriented languages will be accelerated, and such languages will become widely used in the later part of the 1970's.

COMPUTER LANGUAGES AND THEIR USE •

DR. SAMUEL N. ALEXANDER

FOR THE PURPOSES OF THIS PAPER, THREE levels of computer language can be defined. The first level is the symbolic representations of the machine code that are used to activate the computer's built-in reflexes—essentially, the commands to which the computer responds. This level is the starting point for all computer languages, but even the basic level has a good deal of flexibility. Since symbolic languages were introduced, the basic commands of the machine have grown in variety and power. However, there is operating experience to show that a machine can have only 13 commands and still do very useful work. Actually, anything that is expressible in the present more elaborate machine languages can be built up from only three basic commands.

Then why have a larger set of commands? First of all, a primitive set of commands exacts a high price in reduced efficiency. The larger number of commands makes things easier and simpler for the people who are going to write the many kinds of higher languages that make the machine look more sophisticated than it actually is. There was a time when minimizing the amount of electronics was a desirable goal, for both economic and reliability reasons. Whether or not the potential reliability of the internal electronics of computers is achieved depends on how hard the frontier of electronics innovation is pressed. However, prudent practice can today produce machines with hundreds of hours between failures of the internal electronics. Given this possibility, it is perfectly reasonable to produce a very fancy repertoire of basic instructions. Whether or not we take advantage of electronics potential depends entirely upon trade office studies with respect to the investment in the electronics and the cost associated with compiling operating systems and the like. Trade office analysis is not being done very thoroughly by

many companies, but I think we are now approaching the point where it will be.

Use of symbolic representations is important in preparing the languages for the preparation and maintenance of the operating systems, executive routines, monitoring routines, and everything else that makes the equipment more nearly complete, flexible, and easier to use. The designers of these languages can make their jobs easier by more carefully examining the basic structure of the machine. Another use of symbolic languages is in increasing the ability to get an extra measure of performance in frequently repeated operations which do not always require use of one of the higher-level languages for their description. In a few organizations, programs are written in the higher-level language and then examined to find which items recur with the highest frequency. This is sometimes not deducible in advance and can be determined only by empirical examination of the match between the programs and the distributions of the kinds of data put through. If this method is used the programs must be "opened up" and adjusted in machine language.

If very tight time constraints must be met and the machine is just barely able to get under the wire, symbolic languages are often preferable to the higher-level languages. Very carefully tailored programming is still necessary to meet strict time limits, and an improved repertoire of basic commands would be helpful here.

The second level of computer languages comprises the procedure-oriented languages; these are the languages that carry such labels as FORTRAN, ALGOL, and COBOL. These procedure-oriented languages are designed to make

DR. SAMUEL N. ALEXANDER is Technical Director, Center for Computer Sciences and Technology, National Bureau of Standards, Washington, D.C.

fewer demands on the user in translating his actual description of an application into the form that is processable by the computer—in other words, translating into the basic commands of the machine language. These languages are intermediate between the normal means by which, say, the average applications analyst expresses himself and the form in which the computer must have the information in order to execute the tasks the analyst has defined. These procedure-oriented languages are not directly assimilable by the computer, and neither are they the most natural mode of expression of the analyst. However, given sufficient motivation people can acquire skill in procedure-oriented languages and use them fairly effectively, thus making the transition with a better trade-off arrangement on the average than can be accomplished by programming in machine languages.

Success in using procedure-oriented languages depends on the aptitude of the people using them, the extent of their training, and the turnover rate of trained personnel. There are additional considerations involved such as the extra machine time it takes to compile and how much machine time is associated with running the compiled program.

It has been difficult to develop compilers for procedure-oriented languages that result in efficient running programs, although the situation has recently improved remarkably. The cost associated with producing the compilers for these languages and the cost of doing the compilation on the machine must be counted in the total expense of the program. The first cost is hidden in the rental price and the second cost results from extra time spent in the user's shop in getting ready to run. The latter cost is not easily identifiable without some kind of empirical test.

The user has another problem related to procedure-oriented languages. This is the problem of finding errors in the program which appear only when the program is run after compilation is complete. The building-in of means for coping with this type of situation is another area that relates to the costs and the usefulness of these procedures.

In general, the statements in procedure-

oriented languages are at a level of abstraction considerably above that of machine commands, but are still not at the working level of the average analyst who is trying to describe a problem. Certainly he would not normally describe his problem to another colleague in quite the terminology that is called for by FORTRAN or COBOL. This gap in the man/machine interface is leading people to push for another level of language. This third level of computer languages is that of the problem-oriented languages.

Problem-oriented languages are one step closer to a mode of machine expression which is reasonably like the mode of expression the analyst would use in describing his intentions to a colleague. Such languages make the machines more acceptable. With these languages, procedures can be grouped into single tasks. Even today there are some software packages that represent the man/machine interface carried to its logical conclusion. For example, consider the package for preparing a payroll. In the wonderful days to come, the analyst may be able to write out the statement "prepare payroll in accordance with process number," and he will write out a process number and a type-of-payroll number. This is still not quite within reach, but smaller accomplishments of this kind are well within reach. The demand for getting away from the programming and procedural languages has been well expressed by M. E. McIlroy of Bell Laboratories:

We ought to want a set of tools for all our problems. We could get a set of tools for all the problems that were understood at least one implementation cycle ago. Our tools, for better or worse, converge to a highly stereotyped class of FORTRAN-type languages whose differences lie mainly in the thing that is easiest to invent and cope with—improved syntax. The improved syntax is just a . . . simpler and better or easier way of expressing yourself. But you are expressing yourself at a reasonable distance away from the application level.

This seems to me to be a plea for some way of coming closer to man's normal mode of expressing himself.

Thus far, what has happened in the area of problem-oriented languages? One example of progress is the programming package in operation at the National Bureau of Standards, called

"OMNITAB." This is a flexible tabulation procedure that is tailored to the procedure followed by the average experimentalist in preparing for subsequent use data he has gathered in the laboratory. A related large-scale version of this is the type of data-reduction operations that appear on the test ranges for the military and the space administration. He has produced a miniaturized version of the data reduction procedures. The operation uses labels and concepts that the average scientist and engineer learns in his normal professional training: "Use format . . . and print columns . . ."; plot columns . . . and . . . against column . . ."; abscissa value from . . . to . . ."; ordinate values from . . . to . . .". These are the kinds of phrases that are used. OMNITAB was my first contact with problem-oriented languages. There has been a lively debate going on for several years among our personnel as to whether using this kind of language is preferable to writing in FORTRAN. There are advantages and disadvantages to both methods; and it cannot be stated that one is better than the other overall, although a choice can probably be justified by the circumstances of each individual case. Many of us tend to fall into the rather lazy habit of wanting general rules of procedure that make it unnecessary for us to be discriminating. But, if general rules are found that short-circuit the requirement to think, then don't be chagrined if man really is replaced by push buttons in the future!

COGO is a coordinate geometry procedure useful to civil engineers. This language allows many of the civil engineering operations to be prescribed in roughly the language that the civil engineer is trained to use. It is interesting to note that COGO was devised at an engineering school where there was a coupling between the educational process and the computer utilization procedures. Not only did this process give the students tools that made it possible for them to complete more difficult assignments but also the students were able to undertake some of the graduate-year assignments during the senior year—in some cases during the last part of the junior year—because the concepts were straightforward.

With further development of problem-oriented languages, the number of software

packages—each meant for a specific problem and each with its own acronym—will increase greatly. A package called "STRESS" may describe structural stress calculations. There is one for soil mechanics that has the code name "SEPO." Apparently these software packages are going to be generated in profusion. This may pose a real problem: There are hundreds of disciplines and subdivisions of these disciplines, all the way from accounting to zoological classifications. Every one of these disciplines will produce its own package. We will be inundated with problem-oriented packages. What can be done about it?

One thing that can be done is to make sure that these languages are assembled from the human language structure, that these problem-oriented statements are built on what we are already using in the way of procedural statements. This means then that considerable effort must be expended on assembling a set of procedural statements that precisely defines the problem statement. May I point out that this makes the task of finding errors in the system even harder. Assuming that these errors have been flushed out, problem-oriented languages at least give the man closer access to the machine. I think that this intellectual path from the man to the machine is much more important than the characteristics of the terminal equipment. These terminals are important, but the guts of the matter is whether the user can approach the machine with somewhat the same mental outlook as he has when he is working with colleagues or alone. Today he has to change his mode of thinking drastically in order to use the machine.

Experiments have shown very useful first results on typing out a mathematical formula on a moderately specialized typewriter. The formula is typed as a two-dimensional entity so that it appears on paper in the formula format of conventional mathematics symbolism. Concurrently the typewriter also produces a punched paper tape output that contains the equivalent information described by the typist but in a form that the machine can accept as input. With some transformations this input can be made ready for machine interpretation so that the machine then can produce the programming that

is implied by the formula that was written. This is, I think, a very encouraging step along the route. It calls for a terminal device of modest sophistication, but the opportunity for the user to use the machine with predominantly his normal prior training may well offset the complexity and cost of the terminal device.

This concept is also being applied to organic chemical structural formulas. The formulas are put into a computer in such a way that the computer can pick up the mechanized representation and store it in a form that can be searched, ordered, printed, and so forth.

A similar concept, still in the experimental stage, is the adaptation of the computer language to deal with engineering drawing. Certainly, the man in the building trade expresses himself much more often in drawings than in formulas. If the combination of an engineering drawing and the accompanying bill of materials could be properly introduced into a machine, the engineer or architect would be able to review the properties of the resulting structure for, say, its adherence to building code rules. This is within the grasp of programs that now can be written by the machine. It represents another level of approach to problem-oriented languages involving a machine-aided input. (Note that the problem-oriented language absorbs machine-aided inputs and then begins executing the tasks in accordance with easily stated specifications for the problem.)

It is likely that a wide range of problem-oriented languages will develop to keep pace with the number of possible applications. These problem-oriented languages probably can be created by subject-matter specialists. Certainly, this is the goal. An example of an effort where the problem-oriented language statement is created by the man with the subject-matter know-how is the rather extensive experiment that is going on at the Massachusetts General Hospital in conjunction with a firm in the Boston area—Bolt, Beranek and Newman. They have attempted to construct a system with three layers of language that builds some procedural statements into the operating system and makes it possible for a hospital paramedical attendant or research scientist to compose user programs ready to be put into the system and modify or

replace these programs. The efficiency of such a scheme can be improved by use of time sharing techniques. In any case, the opportunity for the user to compose problem-oriented statements is extremely valuable. For example, a pharmacist can write a control procedure for catching inadvertent excessive doses, but this control can be modified by a physician who wishes to prescribe massive doses with good reason. The physician simply builds on what the pharmacist has previously written because it is stated in understandable terms, and he can write in some additional terms or conditions which will blend with and modify the pharmacist's control. Such a system is a goal well worth pursuing.

The problem of software documentation is one that deserves more attention than it is given. Often the user firm realizes the importance and dollar value of good documentation only when it is trapped. Too often, when a program does not run under unanticipated circumstances or needs modification, a user finds that all the people who prepared the program have been transferred, or have been promoted, or have forgotten exactly what they did. In such a case, any effort to try to find out what is in the software package in order to modify it or salvage it necessitates unraveling an already woven garment. This is a very painful process. Documentation of how software packages are developed and, certainly, reasonable standards for documentation are essential to efficient computer operation. Just as the equipment supplier is expected to prove that under working circumstances his compilers do what he says they are expected to do, I think most documentations should contain proof that the software as composed really does everything the specifications call for.

There may be some machine-aided possibilities by which the software could be organized so that the program documentation can be tagged into the compiler. This suggestion was made by McIlroy, and he offers some examples of how this is being attempted. He also says that, if documentation were stylized for the benefit of compilers, it would also become much more understandable to the human readers. In other words, he recommends that there be a tie-in between the structure of the programs and the documentation and that some of the documenta-

tion actually reside in or be linked to the compiler so that the program structure can be traced much more effectively.

There has been a great deal of disagreement and dissatisfaction between the users and the suppliers with regard to the kinds, amount, and promptness of software. The amount of money spent on software is now getting to be so large that it may no longer be advisable to buy the hardware and the software in one package. Serious consideration should be given to the pros and cons of paying the manufacturer one fee for renting his hardware and another fee for using his software. The recent decision by the copyright office that computer programs can be copyrighted makes it possible to treat computer programs in roughly the same way phonograph records are treated with respect to playing them on the air by radio stations. There would be a charge for access to each program and a charge for the number of times it is used. Whether or not the property protection and copyright laws are strong enough to make this a workable sys-

tem can only be determined by deliberately forcing a few test cases to find out how much property right protection a software design can have when put in the hands of a user. Essentially, the problem is not much different from that of protecting the ownership of music compositions, and its solution would open the way for separate purchase of hardware and software. A company then would only buy that part of the software that pertains to its operations. Also, a company would be able to specify the exact software needed and then buy it and protect the investment by acquiring a copyright. Or the company could arrange to have an outside concern create the software and pay a royalty for its use. The outside concern would get the rest of its return by selling to others.

Since software procurement is now such a large economic element in computer operations, it seems appropriate to look at other means for assuring the initial quality and the progressive improvement of software that is used for continued efficient operation.

DESIGN AND DEVELOPMENT OF SOFTWARE PACKAGES •

RICHARD H. HILL

THE SOFTWARE INDUSTRY IS A YOUNG ONE, comparatively speaking. It is hard to know just where to date its beginning, but seven or eight years ago is reasonably close. Six or seven years ago the total market for the services of independent software companies was somewhere on the order of \$5 million a year. Currently, Informatics Inc. alone does business at that annual rate, and the total market for the software industry is probably somewhere between \$75

million and \$100 million a year. This estimate excludes the computer time that is sold by companies which are also in the software business. These figures are my credentials, as a representative of a software company, for discussing the design and development of software packages.

RICHARD H. HILL is Vice President—Programming, West Coast Office, Informatics Inc., Sherman Oaks, California.

At Informatics a software package is defined as "an integrated set of routines and associated documentation to accomplish practically anything that can be accomplished through EDP." Most of the work done by Informatics is of a type that can't be done through procedure-oriented or even problem-oriented languages. Our work is done usually in the language of the machine as represented by symbolic assembly programs, because we are usually called upon to implement systems that are a little bit out of the ordinary. Our specialty area is the field of on-line, real-time, man-machine systems, which are relatively complex. We design and build executive routines and monitor systems, display-programming systems, message-switching systems, and the like. Thus we think of software in terms of systems programs—that is, the programs that support the development of applications packages. However, I don't want to exclude any type of software package from consideration when discussing the problems of design, development, and—particularly—management of software activities. I think that the management problem especially is one that exists on all levels of planning and developing programs.

The basic concepts that were important in the development of modern computing systems are three. The first was the concept of symbolic language; it introduced the notion that one could express computer programs in a language other than that of the computer. This concept was first implemented by symbolic assembly programs, then by procedure-oriented languages, and today by some problem-oriented languages. The second basic concept was that of the generalized routine—a routine once written can be used over and over again as part of many software packages. Generalized routines were first used to do such things as work out square roots or sines and cosines. There are now a great number of generalized routines that do everything from those mathematical functions to sorting, report generation, and so on. The third important concept in the development of software packages was the notion of automatic transitioning from one activity to another, coupled with the idea of letting the computer do some of its own accounting work. From these basic concepts has grown the whole family of systems programming activi-

ties, including compilers, monitor systems, executive routines, generalized input-output systems, and the like. From a management viewpoint the batch-process monitor, in which jobs are introduced to the computing system one after another in a continuous stream, was a most significant forward step. The computer provides the transition from one activity to the next and does the necessary accounting as it goes. However, this is essentially a serial process in which the efficiency of the total computing system is limited by the interaction of the program with its data.

As the relative cost—that is, the cost-effectiveness—of hardware improved it became possible to utilize large segments of hardware for overhead functions and thus make feasible the timesharing of the equipment through multiprogramming. This step made it possible for jobs to be mixed and for the efficiencies of one job to be used to offset the inefficiencies of another. In the ideal situation a computer-bound program shares the computer with an input-output-bound program, and both of the programs together make maximum use of the available hardware.

The feasibility of these approaches really was not established until the current generation of computers, when electronics became so cheap and so reliable as to make feasible the dedication of a significant amount of hardware to the overhead functions necessary to allow such things as multiprogramming to take place.

Now there is a concomitant that must be accepted along with the great capability which is present in the third generation of computers. That concomitant is that all these overhead functions are accomplished by programs and, furthermore, these programs are among the most complex yet encountered. An example of this complexity is a program which has some 10,000 instructions in it, about 80 percent of which are yes-no decisions. The number of paths through that program is literally incalculable. This particular program is a systems program that is part of a large, modern computing system. It is something of a paradox that the hardware for this system is inexpensive and reliable—probably, the hardware is more reliable than the software. But we don't really have any good way of testing the software other than exercising it for a considerable length of time. In this respect, as in

many others, the hardware technology in computing is far ahead of software technology.

This problem of complexity in software to a great extent becomes the management problem of knowing where to cut off the development process. Cutting off the specification process before implementable limits are reached results in control. Anything less is tantamount to allowing invention to run wild.

This concept can be developed a little further. We have seen the use of the term "architecture" in connection with computer systems today. It is an apt term because it refers to the fact that software has developed beyond the point where the programmer is an artist. In effect, he has become an architect. The distinction is this: In the infancy of computing, a man approached a bare computer with an understanding of how the hardware worked and essentially created through his own artistry a program to solve a given problem. He may or may not have left traces other than the code behind him. His artistry was revealed in the code itself, and if it ran it was a wondrous thing. But the modern computing architect cannot afford this luxurious kind of creation. Rather, he has to view his activity as part of a complex, interacting system, just as a large, modern building is a complex, interacting system. The scope of his design activities has grown such that, although one person can possibly conceive the grand design for a large programming system, he cannot possibly hope to carry it out by himself down to the finest detail of design. So, like the architect who designs large, modern buildings, the architect of computing systems must communicate his grand design to his associates and coordinate their activities in its implementation.

This is easy to say, but it is a very difficult thing to do, because this sort of architecture is really in its infancy. Anybody who has been associated with the development of IBM System/360 would agree that the concept of architecture certainly exists there. The implementation has been a matter of infinite pain to a great many people. This is not to say that the implementation will not be good or that it will not be achieved, but the fact that programmers lived through something like that attests to the tenacity of the

human mind and its inexhaustible appetite for challenge.

There are many management problems associated with the successful implementation of a large-scale system. These problems are magnified by the fact that the art of programming really has not progressed to the point where it is able to cope with large-scale efforts on a readily achievable scale. The basic techniques—the tools of our profession—have not been developed to the point where we are able to say with certainty how much, for example, a given program will cost or how long it will take to write it, even after it has been described to us in great detail. Consequently, in our particular business there is a high element of risk involved in many types of activities. But it is the type of risk that we in the software industry are willing to accept on the basis of having had a considerable degree of experience, at least at a certain level. However, for people who do not have a similar reservoir of experience there are no tried and true methods to substitute for the experience. For example, there is no standard way of acquiring, or even stating the requirements of, a program in a sufficiently general form to be able to provide a general solution. We are reduced to the technique of analysis which consists of asking people, "What is it you want?" This question may have to be asked more than once because very frequently people don't know what they want or don't know how to state it. It is not infrequent for people to make changes as the program develops and even after it is completed. This is normal; this is why program maintainers exist. But it does point out the problem of finding a language which is sufficiently general to state requirements and the problem of finding programming techniques that are sufficiently flexible to permit the inevitable changes to be made at minimum cost and minimum risk of introducing new errors.

At Informatics Inc. we identify in the programming process some six or seven basic functions. First, when we attack a problem we prepare what we call a functional specification, which is the initial statement of requirements that we give to a customer and ask that he approve as the basic working document for further

design activities. Once we have agreed on a functional specification, which is effectively a statement of requirements, we produce a program design specification in which not only the externals of a program but also the internal make-up of the program, its various constraints, its reactions with other programs, and so forth are described. When this document is completed to our satisfaction and the customer's, we enter a coding phase. During this coding and the subsequent check-out of the program, we will be doing final documentation. And usually after check-out there will be some additional documentation to complete. Finally we will install the program—that is, bring it to a customer's location, make sure it runs on his computer, and train his people in its use and maintenance.

Note that only two of these six steps are directly concerned with the machine—the coding and check-out phases. The others are concerned with thinking and paperwork. If there were a less traumatic way to prepare documentation than by writing it down we probably would use it. But the fact remains that, in terms of today's techniques, the best way we have of capturing the ideas that go into a program and describing what a program does is by writing it down.

Documentation is all important because we don't document just for ourselves but primarily for other people. And the impression that we make has to be a favorable, lasting one or else we don't get any repeat business. Documentation thus is an absolutely essential investment from a management point of view because, unless the documentation comes with the program, the money spent on the program is in effect wasted, whether it was an in-house development or an outside purchase.

The first law of programming management is not to let programmers make decisions—at least, not until they become something more than programmers. All too often in the past, decisions have been made in the computing shop by default.

To leave important decisions, such as what your programming languages should be, to a person who has naturally a biased interest in the decision—the programmer himself—is to defeat

the effectiveness of the program as well as of the program manager. Programmers don't usually think like managers. They think like people, people who want to take the least painful route to accomplishing a set task and get it over with as soon as possible. These goals unfortunately are inconsonant with management's goals. The first problem of a manager of programmers, no matter what level he is operating on, is to understand that he has to impose some degree of management discipline upon his programming activities or else the whole thing is going to fail.

Programming is a manageable activity, but it takes a high degree of skill and knowledge of programming in order to manage it properly. Programming activities should be managed much like any other engineering or development activity, and it is very important to make preliminary estimates and budgets and to develop detailed schedules. In fact, Informatics uses the PERT technique when its projects are big enough. There should be a rigid and continuing system of monitoring the programming process, which in turn implies that functions in programming situations must be monitorable. In other words, you must establish milestones so that a check can be made to see whether or not the milestones have been met.

It is evident, then, that the important thing for management to understand about software development is the programming process. Reasonable schedules and reasonable milestones cannot be established unless management understands what the programmer has to go through to accomplish his work. One of the problems encountered repeatedly in selling software to private industry is lack of realism in looking at the software development process. This is found less often in selling software to government, where military and NASA have provided a pretty large background experience. But all too frequently, people in private industry expect the specification model to be absolutely correct. Of course, it isn't. Neither are the programs the first time around.

In addition, management must realistically assess the capabilities of its staff—in other words, be sure what its programmers can do. Of the

some 100,000 people in the United States today who are writing instructions for machines, there are perhaps only about 10,000 who are really professional programmers. Finally, sound ways to measure programming productivity must be developed. One of the reasons the whole profession has fallen behind in establishing measures is that the types of programming activities haven't been defined well enough so that we can measure productivity. Measures such as two instructions per hour, 40 instructions per day, and 60 instructions per day are realistic for certain types of programming activity. Yet more complex jobs may be estimated at one instruction per hour, ten instructions per day—and even these estimates may not be conservative enough. The difference, of course, is in the relative complexity of the jobs undertaken.

The amount of documentation also varies from job to job. Some programs may demand

one page of documentation for every 40 instructions in the finished program, in addition to the comments and the listings. Thus, for a system we recently produced that had about 45,000 instructions, there were 1,000 pages of documentation. The documentation included program descriptions, flow charts, write-ups, functional specifications, and so forth. This is a considerably higher level of documentation than most programs produce or even need; for example, a sort run on a well-defined master file certainly doesn't require a high level of documentation, even though there may be far more instructions involved.

When practical measures are established and related to problem complexity, management will be able to use these tools to establish more effective control of software. Efforts of independent software organizations and talented individuals should be directed toward this goal.

VOICE ANSWER-BACK—A CASE HISTORY •

DONALD R. MENG

THE AMERICAN STOCK EXCHANGE HAS A REAL-time voice answer-back facility of great value for Exchange administrative requirements and for the securities industry affected by the Exchange.

Before discussing the actual operation and development of the voice answer-back system, it is necessary to set the stage as to what the purpose of the American Stock Exchange is and, very briefly, what takes place in our market. Edwin D. Etherington, our president, has stated, "The primary purpose of every stock exchange is to create and maintain a fair, free, and orderly marketplace. It can carry out this

mission successfully only if it has a full awareness of its broad public trust and is unfailingly dedicated to integrity."

This fair and orderly market and the responsibility to the public trust are two of the most important criteria in developing and maintaining Am-Quote, our voice answer-back system. What takes place in the market is necessarily in the public domain and has a definite requirement for accuracy and timeliness.

Briefly, a market transaction follows this

DONALD R. MENG is Vice President, Data Systems Division, American Stock Exchange, New York, New York.

pattern: A customer places an order with his broker to buy or sell securities on the basis of quotations obtained by the broker. (In addition to the data about the last transaction, the quotation system has a requirement to know the volume in that stock for the day and what the trend has been today, not only in the subject stock, but also in the market as a whole.) The order is transmitted to the floor of the Exchange by one of several means, none of which is apropos to this discussion. There, a floor broker and a specialist enter into a transaction to execute the order for the customer.

There are two classes of data in the public domain with respect to securities transactions: real-time and historical. (Market surveillance requirements are met by interrelating all of the real-time and historical data in specific modes.) In the quotation data are the bid-and-asked quotations and the price of the last sale in that security. And it is necessary that the data are current, because the general public is making decisions to buy or sell securities in a continuous auction market based on these data.

The historical data concern previous activities of both today and yesterday. They include the price of the last sale today; the net change from yesterday's closing price; today's volume, open, high, low; and, in some instances, time from the last sale. Although referred to as historical data, they must also be readily available because a person buying a security should base his decision on a depth of knowledge about his purchase and should know something of the history of his stock in today's market.

Until 1964 the quotation service was supplied by a battery of more than 100 telephone quotation clerks located in the Exchange building. Quotations were sent via pneumatic tube to a series of operator positions, and some of the clerks physically changed the figures for each of the listed securities on large display panels. Another group of clerks monitored the display and answered direct-line inquiries from each brokerage office. The broker would call on his direct line and ask for information about the stock in which he was interested, and the clerk would recite the information over the line and disconnect. If he wanted the information again

or did not get it, the broker would have to call back. Through this system, it was possible only to get the bid-and-asked and a last-sale price that was probably stale because the clerks could not post the quotations and the last-sale prices quickly enough. It was clear back in 1960, and particularly in 1961, that a new service would have to be offered. After discussions with suppliers, the Exchange decided to proceed with what was then known as The Teleregister Corporation to develop a voice quotation system.

That system became known as Am-Quote. Its vocabulary was established at 64 characters or words. This was a little tight, but it was felt that more than satisfactory service could be supplied. The response time was first established at 400 milliseconds per character, but it was moved closer to 300 milliseconds to meet the needs of brokers for a more rapid delivery.

By dialing Am-Quote, a broker receives the bid, offer, last, net change, volume, open, high, low, and time for any listed security. The information, which is stored in the stock record of the telefile computer, is written onto a drum. Each telephone line terminates on an individual channel on the drum and, if the broker were to miss this on the first try, he could continue to listen to this data until he got the information requested.

It was felt, when this system was designed, that the broker could not afford to receive a busy signal. If he had a customer, he wanted immediate answers. Consequently, there were no concentrators installed in this system. Good telephone practice, of course, would have called for the use of concentrators; but the very time that a broker really needs a fast response—that is, when the market is active—is the time when everybody else needs a fast response. So, regardless of the number of telephone inquiries, there is never a busy signal on Am-Quote. The system was designed to handle 72,000 calls an hour and can be expanded.

An essential part of the overall quotation system is the quality of the data; and, if no quote is available, it is necessary to tell the inquirer why. There are a total of six reasons why there may be no quote; for simplicity's sake, we number them one through six. The term

"none one" indicates that no opening quote has been made by the specialist. "None two" indicates that the stock is very active and that it is impractical to submit quotes that would be up-to-date enough to base an order on. In this case, the salesman must contact his floor broker to get the latest quote from the specialist at the post. "None three" means the quote is being checked. Every time a sale is made, the Am-Quote computer checks to see if the price is within certain predetermined tolerances. If the last-sale price is outside the range of the quotation currently in the stock record, the quotation is purged from the active system and a message is sent to the control center. Here, the challenge is interpreted and corrective action initiated. If an error took place in the input center, a correction message is entered into the system. If the stock needs a new quote, the specialist is notified and he submits a new quote. In the meantime, however, the Am-Quote response reports "none three." "None four" indicates that trading is temporarily halted. This condition may be due to an influx of orders or a pending announcement by the company of considerable significance to the market. "None five" indicates that a stock is suspended, and "none six" means a delayed opening.

The error correction and system monitoring requires a staff of six clerks at the Exchange input center, in addition to the personnel operating the computer at Bunker-Ramo's Tele-Center in lower Manhattan. A staff of more than 40 input operators and clerks is required to maintain the input and filing operations for the Am-Quote system. Although this is a considerable reduction from the 100 clerks employed prior to cut-over, the workload has been expanded to handle trading of five million to eight million shares a day, if necessary. A new service is also provided since the source data are readily available: the sale report slip is filed immediately after transmission, so that a broker can determine the exact time of the trade if he calls a special number.

While the Am-Quote system was developed to function within the context of Exchange trading rules, S.E.C. requirements, the limitations of electronic equipment, and the method

of trading in an auction market, it has not always been possible to enforce some of the rules that were part of the requirement criteria for the development of the system. For instance, the computer has been programmed to print out at 10:05 A.M. in the control center a listing of all stocks on which no opening quote has been received. Sometimes, this list is excessively long and each "no quote" requires action by the correction clerks. In an active market of four million shares a day, it is necessary to follow the rules or the system may bog down. On some days we are required to get relief from the rules in order to maintain the system in readiness. So, if the system is developed to meet rules, it is advisable to be sure that the rules can, and will, be followed when the system becomes operational.

Am-Quote is used primarily by the managing partners and senior people in the member firms; by the registered representatives, or customer's men; and by personnel in the back office. Throughout the Exchange, there are Am-Quote telephones for use by administrative and floor people. There is an Am-Quote phone inside every trading post so that a specialist or his clerk can check the quotation in the stock record to see that his stock is properly quoted. In addition to the 325 direct lines currently installed in broker's offices, there are almost 50 administrative lines within the Exchange. Exchange executives use Am-Quote to check on the operations in the input center. For instance, by checking Am-Quote, it is possible to determine whether or not our tape will start running late or whether additional administrative people are required in the input center to cope with exceptionally high volume. By midday we can usually predict with a surprising degree of accuracy what the total volume will be within one or two hundred thousand shares, merely by listening to the trend and the volume at four successive half-hour periods. For the more volatile stocks, it is possible for the Securities Division, the Surveillance Division, and the Executive Offices to keep an up-to-the-minute running check on each and every stock that is traded and call for corrective action to be taken, if necessary. The Clearing Corporation uses the

information derived by checking on special issues which have split their shares and are being traded on both old and when-issued bases. The last price in extremely active stocks is used for settlement purposes.

This Am-Quote system has been extremely reliable. When outages do occur, they are usually only two to five minutes long. In the almost two years that Am-Quote has been in operation, there has been only one instance of an outage lasting 20 minutes. This particular outage was the failure of the audio response. As soon as the audio was restored, however, the full system was up to date.

Looking back over the history of this program, I think the one thing that we would like to have solved in improving the system was that of inquiry to the system. We would have liked to enter the stock symbol directly instead of converting from the symbol to a four-digit number. This would have reduced the time required for a customer's question to be answered.

Despite this problem, however, Am-Quote has not only satisfied the need for which it was developed—that is, assistance to brokers in the operation of their businesses—but also has been expanded to serve many of the administrative and error-correction functions of the Exchange.

OPTICAL CHARACTER RECOGNITION AS AN INPUT DEVICE •

ROBERT A. GRAY

JUST A COUPLE OF YEARS AGO I THOUGHT optical character recognition (OCR) was the exclusive preserve of the gas and electric utilities, insurance companies, and the credit card companies. The typical sales literature for OCR equipment consistently cited these applications. In the past two years, new equipment and new applications have taken OCR beyond exclusive use by those companies. A growing number of companies are reading sales data directly from cash register tapes, accounting data from journal tapes, premium allowances from coupons, and subscription renewals from postcards. Of even greater impact has been the recent conversion of social security data into a format which can be read by an optical scanner. The list of users is growing by leaps and bounds.

In the past two years, new entrants have been

added to the list of hardware manufacturers. Forms suppliers are also becoming active in the OCR field to capitalize on a growing use of source documents in the OCR machines. In the rather small town of Worcester, Massachusetts, for example, two major forms manufacturers in the past four months have conducted seminars on OCR form design for prospective customers.

Evidently, OCR is a burgeoning field with vast potential. But how does one become involved in its use, and what are the criteria for successful use? Are there options and alternatives? And above all, what are the pitfalls? Perhaps the experience of Thom McAn will help

ROBERT A. GRAY is Director of Systems and EDP, Thom McAn Shoe Company, Worcester, Massachusetts.

other companies to decide whether or not to take the OCR route.

A discussion of OCR at Thom McAn can be conveniently broken down into four sections:

1. The decision for OCR.
2. Selecting the hardware.
3. Designing, testing, and selecting the input document.
4. Preparing personnel to accept OCR.

The decision for OCR. In many ways, this was a decision by default. Thom McAn was looking for a means of gathering from its 850 stores across the nation sales information to form a basis for forecasting and inventory control. The manual systems used for many years provided summarized data only, which are all right for determining how many pairs of children's shoes or how many pairs of sneakers are sold each week; but inventory control relies on specific information and unique identification. In the case of Thom McAn, this means knowing not only the stock number of a shoe but also its width and size. A store with 1,000 different stock numbers would average two widths per stock number and perhaps 12 sizes per width. This means 24,000 separate items for sales reporting and inventory control in each and every store.

To this basic problem are added the facts that our store personnel are sales directed and there is no room on the payroll for a bookkeeper or stock clerk. Thus we needed a sales reporting system that would be:

- Comprehensive enough to provide all required details.
- Accurate enough to provide good inventory control.
- Simple enough to be easily administered in all stores.
- Cheap enough to use so that potential profits would exceed the operating costs.

In our search for this ideal answer, we tried and rejected every possible method of sales reporting yet conceived. One of the methods rejected due to exorbitant cost was to bring all saleschecks (about 500,000 per week) into the home office where the required data would be keypunched and then fed into the computer. From the research for and testing of this method,

we could see the benefit of having a machine to read the saleschecks to eliminate the army of keypunchers required for the job. Unfortunately, we couldn't find a machine to read handwriting directly from the saleschecks. It was when all other methods were rejected that we finally started toying with the idea of revamping our saleschecks to fit a machine that could read the required data.

We were impressed by some of the obvious benefits of an OCR solution:

- The huge volume of paper could be easily handled by a machine at a very low cost.
- The optical salescheck idea would "piggy-back" on the existing system of writing a salescheck.
- Since every sale requires a salescheck, we would be guaranteed a 100 percent reporting base.
- Any cost of saleschecks would be partially offset by the current cost of saleschecks.

Now all we had to do was find a machine to read the saleschecks, design the saleschecks, and see if the idea would work.

Selecting the hardware. At the time we did our initial research, we considered use of the following hardware: (1) Farrington; (2) RCA "Videoscan"; (3) IBM Model 1418; (4) Recognition Equipment Inc.; and (5) Rabinow Inc. Since that time, other manufacturers have entered the scene, and today the choice would require much more consideration.

It is not necessary to indicate why we finally decided on the IBM 1418. It is important, however, to know the criteria used in the judgment.

1. *Cost.* Because we did not know whether or not the system would work and we wished to be flexible in a rapidly changing field, it was imperative that we rent the equipment. At the time, none of us was inclined to commit money to a purchase proposition. Further, some machines required more development than we cared to invest in.
2. *Convenience.* During the long period of system testing, which manufacturer would provide us with test time at a

convenient location? This was an important consideration for we had many theories to prove. After all, no one else had put this idea to use in the manner we proposed.

3. *Compatibility.* This was very important because, although some of the hardware would run off-line, most models had to be run on-line with a computer to obtain maximum potential. If the computer was not IBM's, we would need an interface. Most certainly we could not afford another computer in our installation.
4. *Speed.* The machine had to be able to read the saleschecks at sufficient speed so that it wouldn't tie up the computer all day and so that it could handle peak volume without delay. Some of the equipment reviewed was painfully slow and was rejected on this basis alone.
5. *Reliability and support.* The system we envisioned for Thom McAn called for a daily scanning operation with shoe shipments directed by the computer. Any machine breakdown would mean a system failure, a huge cost in wasted warehouse manpower, and sales loss through nonshipment of merchandise. We therefore wanted a measure of hardware "backup" for the breakdowns we knew would occur.

In our evaluation each of these points was extremely valuable. Perhaps another company would need to consider additional factors, but most certainly these five are of great importance.

Designing, testing, and selecting the input document. The salescheck we had in mind was a comprehensive one based on the "mark reading" principle. This method is similar to mark-sensing, but paper is used instead of card stock, no special pencil is needed, and care in marking is less critical because the reading is optical.

Our first salescheck design provided for the marking not only of shoe sales (by stock number, width, and size) but also of sales of hosiery, polish, handbags, and other miscellaneous items together with the prices charged for them. It was a beautiful form! The only trouble was that it had to be three and a half feet long to hold all

the data. We went back to the drawing board and reviewed the basis of the job: We wanted to get sales data for inventory control, but we did not want to perform the store's accounting work. With this thought firmly in mind, we designed a document to report shoe sales by stock number, width, and size—and no more.

All told, we probably designed 30 different saleschecks, but we tested only three. Since we put our final design into use one and a half years ago, only one minor change has been made. The lessons we learned from the test results of the three designs are as follows:

1. *First design* (see Exhibit 1).
 - a. The perforated feeding edge of the document is ragged and tends to jam the machine.
 - b. The double "width" column encourages people to mark both columns, with resulting inconsistency.
 - c. The "size" column is difficult to understand and calls for three distinct marks.
 - d. The "X" marks and black lines create a "busy" pattern that causes poor marking.
2. *Second design* (see Exhibit 2).
 - a. All the former problems were eliminated by this new design.
 - b. Experience was showing that we needed the store number identification and optically readable serial number for proper handling and for error correction routines.
 - c. We found that three-pair sales were not frequent enough to justify passing all the extra paper through the machine.
3. *Final design* (see Exhibit 3).
 - a. It worked!

We thoroughly tested each design in the field; we encouraged every possible criticism and pressured the participants into finding fault. To make sure the test was complete, we actually placed the saleschecks into productive use in our stores. We used 100,000 saleschecks of the first design and 50,000 each of the other two designs. We wrote the programs to read the documents and provide statistical reports on the

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HOME OFFICE COPY

① Price	STOCK NUMBER	W	SIZE
00000	N	0	0
00000	N	0	0
00000	N	0	0
11111	M	1	1
11111	M	1	1
22222	W	2	2
22222	W	2	2
33333	3	3	3
33333	3	3	3
44444	4	4	4
44444	4	4	4
55555	5	5	5
55555	5	5	5
66666	6	6	6
66666	6	6	6
77777	7	7	7
77777	7	7	7
88888	8	8	8
88888	8	8	8
99999	9	9	9
99999	9	9	9

② Price	STOCK NUMBER	W	SIZE
00000	N	0	0
00000	N	0	0
00000	N	0	0
11111	M	1	1
11111	M	1	1
22222	W	2	2
22222	W	2	2
33333	3	3	3
33333	3	3	3
44444	4	4	4
44444	4	4	4
55555	5	5	5
55555	5	5	5
66666	6	6	6
66666	6	6	6
77777	7	7	7
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88888	8	8	8
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③ Price	STOCK NUMBER	W	SIZE
00000	N	0	0
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00000	N	0	0
11111	M	1	1
11111	M	1	1
22222	W	2	2
22222	W	2	2
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44444	4	4	4
44444	4	4	4
55555	5	5	5
55555	5	5	5
66666	6	6	6
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77777	7	7	7
77777	7	7	7
88888	8	8	8
88888	8	8	8
99999	9	9	9
99999	9	9	9

SALES TAX	AMOUNT
EXCISE TAX	
TOTAL SALE	

CUSTOMER RECEIPT

276520

276520

CUSTOMER RECEIPT

DATE	AMOUNT
MO. / DAY / YEAR	
SALES TAX	
EXCISE TAX	
TOTAL SALE	

① Price	STOCK NUMBER	W	SIZE
00000	N	0	0
00000	N	0	0
00000	N	0	0
11111	M	1	1
11111	M	1	1
22222	W	2	2
22222	W	2	2
33333	3	3	3
33333	3	3	3
44444	4	4	4
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55555	5	5	5
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② Price	STOCK NUMBER	W	SIZE
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11111	M	1	1
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③ Price	STOCK NUMBER	W	SIZE
00000	N	0	0
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44444	4	4	4
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55555	5	5	5
55555	5	5	5
66666	6	6	6
66666	6	6	6
77777	7	7	7
77777	7	7	7
88888	8	8	8
88888	8	8	8
99999	9	9	9
99999	9	9	9

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EXHIBIT 1 (TOP) AND EXHIBIT 2 (BOTTOM)

HOME OFFICE COPY

① Thom McAn ②

1921-89582

STOCK NUMBER	W	SIZE
01 01 01 01 01	01	01 01 01
02 02 02 02 02	02	02 02 02
03 03 03 03 03	03	03 03 03
04 04 04 04 04	04	04 04 04
05 05 05 05 05	05	05 05 05
06 06 06 06 06	06	06 06 06
07 07 07 07 07	07	07 07 07
08 08 08 08 08	08	08 08 08
09 09 09 09 09	09	09 09 09

STOCK NUMBER	W	SIZE
01 01 01 01 01	01	01 01 01
02 02 02 02 02	02	02 02 02
03 03 03 03 03	03	03 03 03
04 04 04 04 04	04	04 04 04
05 05 05 05 05	05	05 05 05
06 06 06 06 06	06	06 06 06
07 07 07 07 07	07	07 07 07
08 08 08 08 08	08	08 08 08
09 09 09 09 09	09	09 09 09

MO.	DAY	YR.	SOLD BY
			AMOUNT
①			
②			
D	SALES TAX		
E	EXCISE TAX		
B			
TOTAL SALE			

EXHIBIT 3

results. Perhaps of even more value than the computer statistics were the long hours of study of the marking techniques and habits of our salesmen. Some of our personnel, posing as customers, watched the operating results on the selling floor and questioned the salesmen who waited on them.

The testing and designing was conducted off and on over a nine-month period. By the time it was over, there wasn't much we didn't know about OCR document design. We were satisfied that the final design was the best we could find for the results we wanted. Note that through this entire period of testing Thom McAn had to carry the ball. There was no precedent to follow, the assistance of the hardware suppliers was absolutely zero, and the largest forms manufacturers in the country provided bad advice. In the field of OCR, you'll find that you will often play the part of pioneer.

Preparing personnel to accept OCR saleschecks. There were many people who had to be convinced that the OCR saleschecks would provide the answers Thom McAn wanted. First of all, although our management was very posi-

tive in wanting the OCR results, they wanted the best possible assurance that the system would work. After all, we were asking for an investment of a quarter of a million dollars even before we read the first document—and this type of expenditure calls for something more than blind faith. Our management probably obtained this assurance more from the thoroughness of our test procedures than for any other reason.

At the same time that we conducted the field tests for document design, we also tested out ideas for training our store salesmen to mark the saleschecks properly. This training phase was vital because we just couldn't afford to send training teams to all the stores throughout the country. We didn't have enough people or enough time. Our plans called for implementation of the OCR system in all stores within an eight-week period. It became very evident that installation at the store level had to be the responsibility of each store manager. He had to be prepared to accept this responsibility and we had to make it as easy as possible for him to train his people.

During the test phase, when we introduced

the test into a new area, the district sales manager was brought into the picture because he is responsible for the administration of 15 to 20 stores. Between the district sales manager and the usual employee grapevine, it wasn't long before most stores in the area knew of the testing. We found that, by enlisting the aid of the district manager and judiciously "leaking" news of the test, the introduction of the saleschecks and training of the people was made easier. In the last test phase we installed the system in 12 stores completely by mail—and it worked.

When the time arrived for installation across the entire chain, the sequence of events was as follows:

- April 15—Letter sent to all district managers outlining the entire plan.
- April 30—Letter sent to all store managers outlining the plan.
- May 5—Talk with district managers during their regular annual meeting. Thorough discussion and training.
- May 10—Publicity notice in the company newspaper to all employees.
- May 30—Distribution of "comic book" and managers' manual to all district managers for their prior perusal.
- June 10—Full-scale story in company newspaper with salescheck glued to the front page.
- June 15—Distribution of "comic books" to all stores.
- June 24—Shipment of saleschecks to all stores.
- July 2—Delivery and installation of 1418 scanner.
- July 6—First 150 stores convert to OCR system.
- July 7—First saleschecks arrive at home office.

How well did it work? Beyond our wildest dreams! All our worries evaporated on that first day. The machine read 98 percent of the documents that first day and hasn't varied much from that level in one and a half years of operation. We clerically review, correct, and key-punch the 2 percent of the documents the machine can't read.

When looking back at the installation of a successful system, it is easy to gloss over the

difficulties and remember the more pleasant elements. This will not be the case at Thom McAn as far as OCR is concerned. We fought too hard to win in the face of a great number of frustrations. A company considering OCR applications may benefit by observing these battle scars:

1. Most OCR hardware is primitive compared with the sophisticated card or tape equipment with which we are familiar. Back-checking circuits are usually absent, and the machines must be programmed to perform some of this validity checking.
2. Optical reading stations are subject to inconsistencies. Don't take for granted that the machine will always read a given document. Of 1,000 documents read perfectly on one pass through the machine, ten may be rejected on the second pass. For this reason, we find that when rejected documents are rescanned 30 to 40 percent of them will be read. On the third try only 2 to 3 percent of the previously rejected forms will be read. Normally, we don't try them more than three times.
3. Much of the machine's ability to read "marginal" data rests on the skill of the service technician. A good one can tune the machine to read "impossible" data. A poor one may let the machine reject half of your documents.
4. Character substitutions are a fact of life. Poorly printed documents have a tendency to provide bad data—"3's" become "8's" and "5's" become "6's." Dirty optic heads and weak signal strengths in the circuitry produce the same results.
5. Personnel with OCR background are very scarce and the assistance available from hardware suppliers is usually superficial or of the "textbook" variety. For the next few years, OCR clients will have to learn mostly from their own trials and errors.

This evaluation of one company's experience with OCR may sound like a warning to stay out, but its purpose is quite the opposite. We only wish to point out the practical con-

siderations involved and the work that must be done to make a sound business decision.

Let's look at the advantages to Thom McAn:

1. Without OCR, we could not have done the job. The problems were so complex and the data so voluminous that no other system was practical.
2. One OCR system leads to another. It is so practical to let a machine read our source documents that we have branched out to capture new applications.
3. Finally, the potential of OCR is appealing. In spite of our labors, we haven't scratched the surface of the potential of even today's rather primitive equipment.

Earlier, I mentioned Thom McAn's wish for a machine that would read the handwriting on saleschecks. Such a machine could be programmed to read vouchers, cash reports, invoices, stock receipt tickets, and so on. In effect, we could bring all source documents into the machine and bypass the keypunch operation.

We could then obtain our data much faster and much cheaper. We could install many applications now impossible because of the expense or delay in translating source paper into machine format via punched card, punched tape, or some other means. Truly, such a machine could revolutionize current approaches to EDP and open up an entirely new phase of business technology.

At the New York World's Fair, one computer manufacturer displayed a machine that could read handwriting. Over the two-year period the machine read the handwriting of millions of people. The experience gained from that display should materially assist in the development of a commercial machine to read all handwritten business documents. It is no secret that Thom McAn is anticipating the marketing of such a machine in the near future. We're getting ready for a new and simpler approach to data input that will open new doors for all of us.

KEYS TO A MANAGEMENT INFORMATION SYSTEM IN YOUR COMPANY •

ADRIAN M. McDONOUGH

THE FIELD OF MANAGEMENT INFORMATION systems is so new, and is changing so rapidly, that it is impossible for anyone to really qualify as an expert. It is the very rate of change that causes many of our present difficulties.

The period in which we live always appears to us to be the one in which the greatest changes take place. The present is no exception. Today we face a world where new philosophies and new technologies are being proposed, tested, and absorbed at a rapid rate. The growth of knowl-

edge has reached a point where it has become a burden and, therefore, a challenge. This challenge is apparent when we consider the problems of organizing information to serve the appetites of all who would enlarge their personal knowledge. More specifically, in business and govern-

ADRIAN M. McDONOUGH is Professor of Industry, The Wharton School of Finance and Industry, Department of Industry, University of Pennsylvania, Philadelphia, Pennsylvania.

ment organizations we see large amounts of manpower concentrating on the search for facts and upon the interpretation of these facts.

The opportunity thus arises for studying the productivity of knowledge and particularly the productivity of management information systems. Productivity has in the past been associated with physical production. The "Taylor Movement" in the United States and the "Stakhanov Movement" in Russia resulted in greater understanding of the problems of physical production. Factory jobs were carefully analyzed and improvements were made at every level of the conversion of raw material to finished product.

Now there is a need for extending the concept of productivity to include all who work with facts and figures—those who collect, process, and interpret information. In the past such work has been treated as "nonproductive" labor. Today progress is increasingly dependent upon the efficiency with which we convert facts and figures into useful products as knowledge for management decisions.

The information in this paper is derived primarily from the work I have done in the field of information economics.* The work in information economics includes an exploratory attempt to define the problems of measuring productivity for "facts and figures" jobs. Facts and figures influence every administrative job from the lowest clerical positions to the top executive positions. Facts and figures influence the goals, the processes, and the results of all organizations. My approach, therefore, proposes that information be treated as a product and that both the values and the costs of information as a product be studied in the tradition of the scientific method. The ideas of information economics and management systems are presented with a hope that others will find them useful as they develop their own views of the productivity of information.

The title of my paper is "Keys to a Management Information System in Your Company."

* McDonough, Adrian, *Information Economics and Management Systems*, McGraw-Hill Book Co., New York, 1963; and Adrian McDonough and Leonard Garrett, *Management Systems, Working Concepts and Practices*, Richard D. Irwin, Homewood, Ill., 1965.

Keys, of course, are useless unless we can locate the right doors to unlock. Also, keys become obsolete when locks are changed. We must give due consideration to which doors we want to open and, especially, to why we might want to open them—and, remembering Pandora's Box, to why we might want to keep some doors closed.

The game of predicting what is going to happen in this field has been going on for some time now, and the stakes are getting higher all the time. This is apparent in the symbol of the third generation manager. We are no longer viewing data processing with a scope limited to machines and programming. Now the dimensions of the approach branch out to include all levels and specialties in an organization's list of positions. This means, of course, that not all of the locked doors are located in the machine room. We are now seeing that there are very few boundaries to where data processing might have an impact in an organization.

It is for this reason in particular that I have selected a few specific areas and will direct my remarks to them. These are areas that I believe should be of interest to the systems analyst, as well as to any manager who recognizes the importance of management information systems. I will comment on five locked, or at least sticky, doors that should be opened when seeking success in management information systems.

If we are to get behind the locked doors, I propose that the following five are among the most important keys:

1. Surveillance.
2. Criteria.
3. Classification.
4. Documentation.
5. Boundaries.

It is my impression that each of these areas contains fundamental restraints to the development and use of effective management information systems. Our systems can be no better than the state of the art in handling these problems.

THE FIRST KEY: SURVEILLANCE

Surveillance refers to all those activities by which a better perspective on an organization

and its environment is obtained. It includes coverage of both external and internal situations. It includes immediate and longer-range circumstances. In effect, it can cover every aspect of an organization; but, practically, an organized surveillance effort must be very selective.

I believe it is useful to think of surveillance as limited to the search for major changes in the environment of a firm. Surveillance of the environment of a firm is made difficult by the very fact that its purpose is to bring out and highlight those factors which require management to make changes. The management that is demonstrating its ability in the face of change does so by devoting resources to a very selective surveillance of its environment. Such a management not only looks inward at its base of operations but also goes out into its external environment in order to get firsthand knowledge.

Surveillance can be very informal, but more and more organizations are providing formal arrangements for certain aspects of surveillance. The payoff here for management information systems is that good surveillance can provide the best guidance for what should be included in the formal information systems. This is especially so in situations where change is typical. Progress can be made only if good evidence of where we are and good statements of where we want to go are available.

Surveillance can be viewed as a level of analysis one stage ahead of the actual design of the information systems. A good surveillance program, in this sense, is insurance that good specifications can be set for keeping systems design up to date. We need a better framework in which to design and evaluate our management information systems. A good surveillance program is one of the keys to getting better design and evaluation.

Consider the reality of the world in which we live. What is stable? What is not subject to change? Certainly not our information systems! Attention to surveillance will prevent the development of rigor mortis in our systems. Today's systems design must include flexibility to accommodate future changes. A priority given to surveillance arrangements, at a minimum,

can lead to the writing of better guidelines for systems success.

Let me go back over this point, because it is a difficult conceptual problem. Systems should not be designed in a vacuum. For any situation of significance a manager can ask, "What is it?" and, "What should we do about it?" At any point in time and experience, a first glimmer of a situation may appear. The difficulty is, of course, that the situation is rarely clear. In many business situations we are not sure of the factors, their significance, or their interrelationships. It is in the context of such vague situations that management problems are first identified and stated. This is the threshold level where the preliminary question is asked and the problem is stated for the first time. In the final analysis, no system can be evaluated except as it serves some purpose. The purpose can be spelled out only as we are able to provide effective surveillance of situations. We thereby obtain up-to-date descriptions of our information needs.

I am suggesting that more formal attention be paid to how our organizations carry out their surveillance activities. This will open the door to more concrete statements of the criteria with which information systems can be evaluated.

THE SECOND KEY: CRITERIA

Criteria, or measures of performance, have up to now been a rather academic exercise; this can no longer be the case. A major problem in government and industry is that we are spending fantastic amounts of money on systems and we do not know how to evaluate what we are getting for our money. We know what those systems cost, but we do not know what they are worth. Here is a real key to success in management information systems: concentrate on getting the real measures of the performance we should expect from our systems. This is the only way that I can see to do a better job in evaluating: (1) what the \$5-billion computer industry is achieving and (2) what over half of the people who work for a living in this country are achieving. The information industry is at least this big, and it is growing every day. What are the results of all this investment, all this time-consuming attention to information? Again, the answer can

be found only as we develop the analysis of criteria, the language in which we express values.

If we want to be able to evaluate the outputs of our systems we must be willing to spend more time and effort being specific about what we want from these systems. Getting to a better level of specifics requires that the managers themselves concentrate more on the formal expression of criteria involved in their jobs.

My assumption is that information systems serve managers in their job responsibilities. The reverse assumption, which is being made too often, is that the managers exist to serve the information system. It is because of this second assumption that we see so many conferences entitled: "The Impact of the Computer on Managers." The need today, however, is to look at the question of the "Impact of Managers on Computers." We are at a point where it is primarily the managers—not the hardware—that determine success or failure.

No matter how sophisticated the management information system is, it has to serve some level of management. The identification of the criteria appropriate to management at that level gives the best means to place values on systems outputs. Identification of criteria associated with various organization levels can provide a relatively crisp structure of an organization's decision needs. An approach that concentrates on criteria can get very close to spelling out the values that should be provided by a management system.

Much searching is now going on trying to find some way to put dollar values on information. I think that this is the wrong approach. We should be thinking in terms of the *real* measures of information values expressed in the criteria and units that fit the situation. Let me just note at this point that the Ten Commandments and man-made codified law provide important criteria for performance evaluation without using dollar units. In forcing our measures into dollar units, we may be distorting them to the point where they are useless. In budgeting, for example, the jump from the identification of problems to the assigning of dollars may

take place too fast. We tend to focus on the dollar figures in the final budget rather than on the analysis at the level of spelling out problems and their related criteria. I suggest that the budget procedure is one good place to start finding and using better criteria for information systems.

When criteria are not clearly spelled out, it is necessary to make forced choices—that is, choices based upon hunch and intuition. The study of criteria is one of seeking gradual improvements that will reduce the dependence on hunch and intuition. When good criteria are available, management can have more confidence in the answers to its questions.

The environment of an organization as it generates problems is the prime reason for any work in management systems. Problems reflect from situations where opportunities may be obtained or where hazards can be prevented. From a given situation at a moment in time, an organization seeks to take actions that will increase its opportunities and at the same time to take actions that will reduce its hazards. As the organization moves through its environment, individual participants identify their place in the scheme of things. They consider their organization position level and the time dimension of decisions for which they are held responsible. It is at such a time that the individual uses his management ability to identify the problems on which he will work and, at least intuitively, starts to assign priorities to his problems. In so far as his opportunities and hazards are synchronized with those of the overall organization, he weights his problems by their importance to the organization.

When the individual recognizes a lack of consistency between his personal interests and those of the organization, he is faced with the forces of compromise. The scales of opportunity and hazards that he sets for himself will be balanced by the repercussions he can expect if he gets out of line with the best interests of the organization. In any case, if the individual is to make logical decisions and is to take logical action, he must be as explicit as possible regarding both his opportunities and his hazards.

Again, he must select and express himself in statements of the priorities and criteria peculiar to his situation.

Criteria statements are logical extensions of initial problem definitions. They provide at least preliminary bench marks for testing the success of a project. Criteria are the English words with which we express the bases upon which we make choices. Any system that purports to aid decision making should be designed with conscious attention to criteria. Criteria become more meaningful when we are able to attach weights to the English words and thereby to make relative comparisons. This type of thinking is important in designing a system. It is especially important when attempting to set priorities among systems. Criteria statements can be quite useful when a management is attempting to compare and contrast projects and to set meaningful priorities.

Success in any job, at any level, must be measured against some set of criteria—some set of statements that separate the important from the unimportant. A manager in any job at any level has to:

1. Try to find out the criteria used by his superiors and, if appropriate, to help set such criteria.
2. Identify the criteria involved in his own job.
3. Provide criteria for subordinates.

Only as improvements are made at and among the levels of criteria is it possible to write meaningful specifications for the values that should come out of information systems. Criteria, I repeat, are the words in which values are expressed.

When I use the word "value," I am including two shades of meaning. The first is the type, or class, of what is being evaluated. This involves selecting the appropriate criterion. The second is the scaling, or attaching of a degree of importance. This involves putting weights on the appropriate criterion. To identify any value, therefore, a criterion must be selected and then a weight must be attached.

Criteria are necessary to spell out the responsibilities of a manager. They are, therefore,

necessary in spelling out the information systems that must support the manager as he tries to carry out his responsibilities. It is for this reason that I define information as "evaluated data." This definition allows us to tie information values directly to the selection of the criteria for success of any organization.

If we want to be able to do a better job, we must be willing to spend more time and effort being specific about what we want from our systems. This, in turn, may mean that we will have to cut back somewhat on the so-called total systems some of us are trying to build. There may not be enough resources to do a big and a good job at the same time. Getting to a better level of specifics requires that managers concentrate more on the formal expression of the criteria involved in their jobs.

Only as we make progress in expressing criteria in the job context can we expect to be able to attach values to our information systems. In a changing world, problems will change; and we must expect job content and systems content to change. Attention to the level of criteria can facilitate the implementation of such changes. No matter how sophisticated the management information system is, the manager must attach his values if he is, in fact, to have a job. Identifying criteria is a major part of his job.

THE THIRD KEY: CLASSIFICATION

Classification is another key area that is holding up progress in information systems. All information systems depend on classification, yet we really have very little knowledge about how to build good classifications. Work in classifying anything is tedious, and most people shy away from such work.

The importance of classification in information systems is, however, gradually being recognized. Classification is the very beginning of the organization of facts and information. Without classification there can be no information systems. Unless something is first classified it is impossible to measure it. With bad classification even the most powerful management

science techniques can be made ineffective. It is time to look at the problems of classification more carefully.

The decision to establish a business class, or to use an existing class, is the threshold at which we determine that a certain factor cannot be ignored. The identification of a factor as significant is the justification for including that particular factor. The recognition that classes should be selected carefully is a major step in minimizing the detail in an organization's systems.

There has been a tendency to build data processing systems upon existing classifications. Now we find that we have large investments in programming using these classifications. Such classifications are usually oriented toward use in quite separate functions of the business. Now we want to get integrated usage from our systems. If the classifications are not integrated, how can we expect to get integrated results from the systems?

We do not want *all* the facts—we want very selected facts. A selected fact is information. Selection should start with the classifications from which we build our systems.

Classifications are the building blocks of representations. These blocks can be big or small, gross or detailed; it is the critical job of the developer to match needs with an appropriate coverage of classifications.

A classification is a grouping of items of similar characteristics into classes or sets. This is not, however, a sufficient definition, for it ignores the need for identifying what we mean by similar characteristics. Further, it ignores the needs to treat differences as well as similarities. Let us look at this point more closely.

An overall classification development requires consideration of both differences and similarities. Similarities are sought so that they can be brought together in one place and worked on with a relatively uniform approach. Differences are sought in order to recognize when different treatment must be applied to the classes. A class, therefore, represents a grouping within which the subclasses fit together in relative harmony. These subclasses have meaning in the sense that they form the class as a whole. Contrasts of classes, however, emphasize the

need to identify differences and the significance of these differences.

This running back and forth between similarities and differences plays an important part in the development of a useful classification system. The fundamental idea is that classifications are built to facilitate decisions. Decisions involve both the making of comparisons for similarities and of contrasts for differences. In a good classification system, certain significant comparisons and contrasts are already built in.

Consider the mass production approach now being applied to the development of centralized data banks. If these banks are built before the classifications are carefully studied, they may simply turn into massive collections of unusable equipment. Data collection can become even more expensive and the results can become utterly useless. Classifications are very much involved in the quality control aspects of producing information products.

THE FOURTH KEY: DOCUMENTATION

Documentation is a real key today for those who are trying to keep track of all the details involved in the development of information systems. By documentation, I mean a recorded set of evidence showing the characteristics of some part, or all, of a management system. As our systems get larger and more complex, we are being overwhelmed by the expanding amount of detail. If we cannot keep track of what is in our existing systems, how can we ever make comparisons between existing and proposed systems?

Documentation of a system, or parts of a system, can be done in a careless or in a careful manner. In some cases, scratch pads and all other working papers are thrown in a file drawer (or perhaps a wastepaper basket). At the other extreme, every detailed decision made is carefully reviewed, indexed, written up in some standardized manner, and filed for easy retrieval. Both extremes are rare; actual practice is usually somewhere in between.

"Documentation" as a term is usually reserved for describing work at the levels of systems design and computer programming. It is here that we see explicit flow charts, pro-

gramming instructions, and computer-run manuals. I include other areas when I use the term documentation. One of the big areas where documentation needs to be improved is in those stages before systems design. In particular, I am referring to the needs for providing much better analysis and documentation of the specifications of information requirements. Only as these requirements are carefully chosen and documented is it possible to formfit the design of the system to individual manager's needs to know. Typically, information requirements will be expressed in the vocabulary of the manager's field of specialization, and this is just the way it should be.

Systems design is not the first step in the development of a management system. Unless the steps of problem definition and determination of information requirements are carefully documented, the stage of systems design may start with no clear-cut objectives—and this happens too often. What happens is that the systems designer, by himself, creates *his* problem definition and *his* view of the information requirements.

I believe that more formal pressure is being placed, and rightly so, on managers to provide the specifications for what they want out of information systems. This, of course, is where many of our programs for management information systems run into difficulty. It is not easy for a manager to spell out the information requirements of his job. Yet, if he does not, who can? If he does not, how can we expect better information? The frustrations existing here represent a key restraint to improvements in our systems. We are starting to see increased attention being paid to getting managers to become converts to information systems. This is anything but a simple problem. Flag waving and statements that the manager is responsible for setting his information requirements are not sufficient to get results. Managers must be given help in defining their information needs. An organized effort in a company documentation program can be a good start in helping managers to express their needs.

A documentation program in a company can serve as a rallying point for gradually improving the effectiveness of management infor-

mation systems. Documentation touches every level and every specialty in an organization. The variety of "languages" used in operating a business can cause confusion and consequent inefficiencies in operations. Documentation, at a minimum, highlights these problems. It gets them out in the open where something can be done about them.

Consider the possibility of having a manager's information "menu." This would be an organization's documentation of what can be available in existing information systems. The availability of a menu makes it possible to identify the set of choices for the manager and guides the systems designers as improvements are suggested. The menu of information available that can be served to managers can be viewed as the documentation of the important systems in the organization. With the information menu available, both the manager and the systems designer have a positive basis for discussing systems requirements.

There is a major need to have available much better means whereby the content in management systems can be identified and analyzed at various levels of detail. Progress in documentation will aid in the following situations:

1. Where add-on systems are being proposed.
2. Where systems are to be dropped.
3. Where the effectiveness of a given system has been challenged.
4. Where cross-relations within and between systems are to be studied.
5. Where audits of any nature are to be performed.
6. Where a new management technique has become available and consideration is being given to changing systems to exploit the improvement.
7. Where an approach is needed for penetrating parochial defenses of decentralized systems by reducing some of the barriers of complexity behind which parochial interests can hide.

Present methods for handling these problems are quite inadequate. At best they depend upon a voting process used by experienced people in the organization. More formal rules and techniques are needed to reinforce the judg-

ments of these experienced people. There are just too many detailed pieces involved in systems content to make much progress without some sort of an organized approach to improving documentation.

THE FIFTH KEY: BOUNDARIES

Boundaries represent the last key area that I will discuss. Here, I am afraid, we are being misled by all this talk about "total systems." The present quest for total systems should be recognized as a hazardous quest for the ideal. If the use of the term "total systems" leads to the impression that it is simple to integrate systems—or if it is only a merchandising slogan—then the term should be discarded. It is better to think of a system as being made more complete or more comprehensive. The question, "Should certain systems be integrated?" is just as important—if not more important—than the question, "How can these systems be integrated?" When nature puts certain odd systems together the result is often a freak. Managers and systems designers must guard against integrated but freakish systems.

As we try to increase a system's scope, or take on larger problems, there are compounding complications that set up restraints. We should recognize these complications and build our systems accordingly. Total systems are not good in and of themselves. In the production environment we had something like a total system years ago when one very large motor would drive many machines through a series of belts. Then it was found advantageous to set up separate systems with individual motor drives on machines. It was only when we were able to conceptualize the overall relationships of individual machines that we were able to move to integrated production systems, and even now this covers only a small percentage of our physical productive capacity.

A significant area of systems design is the setting of boundaries in which systems can operate with some measure of self-policing. The setting of boundaries is a key part of any problem definition. In practice, problem definitions are usually developed to the limits of compre-

hension of those involved in their design and utilization. We cannot design systems boundaries that go beyond our ability to define our problems. At some point things go out of focus and out of control.

We must not let the drive for progress put us in the position where we make promises that are impossible to keep. Too often I find false fronts on the stores that are peddling total systems. These merchandising outfits worry me, but it is their customers who buy the panaceas that worry me a lot more. A concentration on the problem of boundaries can quickly demonstrate the need for clear separation of systems.

Notice how the four areas that I discussed earlier all lead up to this problem of setting boundaries for separate information systems.

Surveillance, or lack thereof, sets limits to how well we see many of our most critical problems. Surveillance, therefore, greatly influences how many missing parts there may be that are not yet subject to integration through the systems approach.

Criteria must be available if we are to make decisions about the value of the services provided by an information system. Systems integration should take place only when we can meaningfully relate the criteria in the enlarged scope of the problem we have defined. In general, as we extend the boundaries of our analysis, we must be prepared to develop more explicit criteria.

Classification I described as the first level of organization of facts and information. Inadequacies and inconsistencies in our classifications are major restraints to our attempts to take on larger systems.

Documentation involves getting good descriptions of our problem definitions, of our information requirements, and of the logic of a system which can meet these requirements. The amount of effort now going into the seeking of better methods of documentation indicates that we are having a terrible time describing what already exists in our present systems. Note that many times we do not really tie separate systems together. In fact, we often cannot describe what exists and we start all over again trying to get the new and larger system.

In the area of management information systems the big challenge now is to tie systems content to job content. We are back with the emphasis on organization problems and are asking, "How can authority be balanced with participation?" We are starting to think about ways to relate the talents and the techniques available in an organization.

Talents are recorded in the minds of managers, and techniques developed by talented managers can be recorded in systems. Thus, one of the challenges of talented people is the need to provide good techniques. Such techniques are then put to use to make easier the handling of the organization's recurring problems. In simplest terms, a good technique records the use of good talents. The talent is built into a technique, applied as a system, and used over and over again.

A manager who believes that he can run his job without systems is mistaken. A systems specialist who assumes his system can run

the organization is mistaken. The emphasis should be on the extension and blending of management skills. A management should think of its systems, as well as its personnel, as being skilled. Skills in this sense can be built into a system.

This skill conversion is a vital link between the interests of the manager and the systems specialist. It is in this area of relating the manager's job content and systems content that I believe big payoffs can be achieved. The keys to this problem are improvements in the areas of surveillance, criteria, classification, documentation, and boundaries.

All things are somehow connected. There is, theoretically, in the ultimate, a wholeness. The basic fact is, however, there are so many things and, therefore, so many connections that man can work forever and yet discover only a small part of what there is to be known. I recommend the incremental approach to getting bigger and better systems.

IMPROVING CORPORATE PLANNING THROUGH ELECTRONIC DATA PROCESSING •

DR. ROBERT S. WEINBERG

THERE IS A GREAT INTEREST IN AMERICAN industry today in concepts of planning. About a year ago I undertook a serious study of planning practices in industry, and I met with the board chairmen, presidents, and chief executive officers and other senior executives of some of the largest companies in the United States. I was interested in what management expects from planning and, indeed, in what "planning" is. I reached some conclusions that are not startling. First, planning is as much an art as it is a science.

Second, planning is highly quantitative in nature. In fact, this might be one of the few top management interest areas that are indeed quantitative. Third, planning requires competent professionals. Fourth, planning must have management support and understanding; this is difficult to achieve.

DR. ROBERT S. WEINBERG is Director of Analytical Services, International Business Machines Corporation, Armonk, New York.

After searching the literature and looking at the work that has been done, I came to the conclusion that there are probably five kinds of people involved in planning. The first group includes the list-makers and the framework-builders. They tell you exactly what to consider but never how to consider it. I would say that, until quite recently, this group dominated the literature.

The second group is closely related: they are the inventory-takers. The inventory-takers can tell you exactly what everybody else is doing but not what you should do.

Next are the philosophers and theorists. These are the people who tell you what to do conceptually but avoid doing it.

In the fourth group are the wide-blue-yonder boys. They tell you exactly what is coming tomorrow but give you little insight as to what to expect today.

The fifth group is the group that I think is achieving the most. I call these the parametric thinkers and the professionally qualified guessers. Corporate planning is in many ways a great guessing game—one that is extremely important to the health and welfare of any company. The odds can be narrowed if this game is played with a computer, for then the players are in command of the information.

Four things have happened that have changed management practices. First is the increased availability of timely and accurate data. The second is the virtually universal availability of computers.

The third is the availability of a body of analytical knowledge—call it management science, call it operations research, call it quantitative common sense—it doesn't change the fact that there does exist a body of very powerful analytical tools. When I was a graduate student, we used to say you can ruin the mathematician by finding some practical use for his output. I think this has ceased to be the case. Primarily as a result of World War II, physical scientists and other analytical thinkers have developed a strange kind of union with policy makers and have provided all sorts of extremely powerful analytical tools.

The three factors I just noted provide a

logistical base for changes in management. The fourth factor, which creates the necessity for these changes, is the rapid change in the business environment. It is almost impossible to find a situation in the history of American business prior to the end of World War II where a single erroneous decision wreaked havoc in a large company. There are many situations where many poor decisions led to havoc; but there were marvelously few single decisions that had disastrous effect. Since World War II, however, there have been dozens of situations where a single erroneous decision was seriously detrimental to a company as reflected in the company's profit-and-loss statements. Does this mean that managers are getting dumber? Hardly. Managers today are far more professional and far more technically competent than managers have been in the past.

The reason is that business has become more complicated. In fact, I think the toughest realization for anyone who attempts to do analytical work involving management problems is the discovery that everything depends on everything else and that this dependence is influenced by many different things.

Through interviews with top executives I have come to the conclusion that most executives are concerned with seven broad management activities:

1. Setting the company's short- and long-term objectives.
2. Determining the company's overall policies.
3. Making or approving decisions that have significant impact on the company's future profits or operations with particular emphasis on promoting innovation.
4. Coordinating several major corporate functions.
5. Developing and maintaining an organization of qualified subordinates.
6. Delegating responsibilities and authority to the organization.
7. Controlling performance and results through at least one level of supervision.

I think these tasks, taken collectively, are the actions that distinguish top managers from other executives. Almost every top executive I spoke

to felt that working toward the achievements of the company's overall objectives was his own first objective. And for most of them planning and setting the company's policies and objectives ran a close second.

Probably not more than 2 percent or 3 percent of the large companies in the United States have established a meaningful set of corporate objectives, yet these objectives represent the very framework within which the strategies of the company will be established.

There are three approaches to planning. *Strategic planning* is concerned with the determination of objectives and with the selection of the most attractive combination of available alternatives for achieving these objectives. This area is almost wholly within the province of top management. *Tactical planning* is concerned with determining the most efficient use of the resources that have been allocated for achieving an already specified objective. The third area is *operating planning*, or *budget planning*. It is concerned with the development of a control mechanism to assure the effective implementation of the action specified in the strategic and tactical plans and with providing the basic measurement of actual performance relative to planning. All three approaches to planning are important to management and are indeed of great interest to management; however, my discussion will be concerned only with strategic planning.

DEVELOPING A STRATEGIC PLANNING SYSTEM

Relatively few companies do strategic planning. Why? First of all, the concept of strategic planning in business is a comparatively new one. The need to develop the strategic planning system is also new. In addition, the development of the meaningful strategic planning system involves a level of management participation and an availability of information that were not previously possible. Finally, it is a great temptation in business to be preoccupied with immediate problems at the expense of meaningful long-range planning.

I mentioned before that relatively few companies have established objectives in a meaning-

ful way. In general, the management of a company that is out-performing its industry has the corporate objective to maintain the position of leadership. The company that is performing poorly, relative to the industry, has as its objective to improve its performance. In general, a company with a profit margin of 6 percent and a growth rate of 8 percent wants to maintain a growth rate of 8 percent and a profit margin of 6 percent in the future—that is, as long as this growth rate and profit performance at least equal total industry performance. Very few companies, however, know how to look at the alternatives that are available for consideration. But the first step in establishing corporate objectives and corporate strategies *must* be the preparation of a list of these alternatives.

Why should management be involved in strategic planning? The planning process focuses management's attention and judgment on problem areas and, more significantly, on potential problem areas so that action can be taken to avoid problems before they arise. With computers and mathematical models, it is possible to look at many different alternatives. In talking to managements of companies that had embarked on major diversification efforts, I was amazed to learn that, more often than not, no more than two or three alternatives were considered.

The strategic planning system itself should provide a basis for looking at specific alternatives and specific opportunities to see for each opportunity what will happen to the business if it is accepted or is not accepted. The system will provide a basis for conducting feasibility analyses to determine what resources are required to launch a new undertaking and whether the company can generate them.

In designing a strategic planning system there are some technical requirements that should be considered. First, developing a set of objective criteria for measuring the company's performance is the starting point of management planning. Often the annual reports of leading companies include such statements as "We grew 8 percent this year, which is the greatest annual growth rate in the company's history." Frequently, however, the growth rate for the indus-

try in that year may be greater than 8 percent. So, on a relative basis, the company is doing poorly. Thus, establishing a basis for measuring *actual performance relating to potential performance* is extremely important.

Developing the capability to perform analyses in marginal or incremental terms rather than in terms of averages is the second requirement for a strategic planning system. Possibly the most frequent mistake made by businessmen is allocating resources on the basis of the average rate of marginals. That is, the company should plan in terms of what an additional \$100,000 in advertising or sales promotion will bring rather than determine the average rate of return on the first \$1 million spent and expect this rate of return on \$1,100,000. Very often a company will assume that if \$2 million in advertising produced \$30 million in sales, \$2.5 million in advertising will produce \$37.5 million in sales. Such reasoning can easily lead to the miscalculation of resources. This is an extremely important point, a point that a formal planning system will enforce.

A third requirement is to carry out the analyses and evaluations in the most meaningful levels of aggregation. If too much detail is considered, the system becomes too cumbersome. If, however, the analysis is too aggregate, important structural interrelationships will be lost in the aggregation process. The aggregation problem becomes important when several different individual products or market sectors are added together to develop a product or market group total. For example, it is possible for a company marketing in two or more submarkets to observe a completely different picture of their operations if an evaluation of their performance is made on a total market basis rather than on a submarket basis. The competitive performance of the American Tobacco Company from 1950 through 1959 offers a dramatic example of this phenomenon.

Company sales and brand sales data for the cigarette industry indicate that American Tobacco's competitive performance was favorable during the first half of the decade and highly unfavorable during the second half of the decade. In the absence of any further data we

might reach the conclusion that something went wrong with the company's marketing programs. If, however, instead of considering the cigarette market as a whole (a high level of analytical aggregation) we disaggregate the market into four submarkets representing the four types of cigarettes being marketed (regular, king-size, filter, and mentholated), a completely different picture emerges.

1. In 1951 the company's share of a major submarket (regular cigarettes) was down, but the increase in its share of the king-size market (and the increased importance of this market) created a situation where its share of the total market increased.
2. In 1952 the company's share of both markets in which it operated decreased, yet its share of the total market increased.
3. In 1953 the company suffered a major loss in the king-size market and a slight gain in the regular market, yielding a slight decline in the total market.
4. In 1954 the company made substantial gains in all three of its submarkets but registered only a slight gain in its share of the total market.
5. In 1955, 1956, and 1957 the company increased its share of market in each submarket in which it operated, but its share of the total market declined.
6. In 1958 and 1959 the company's performance in each of its submarkets was significantly better than its total market performance. (This was particularly true in 1959.)

It is interesting to note that in four of the nine years studied (1952, 1955, 1956, and 1957) American Tobacco's market performance in each of its submarkets was exactly the opposite of its performance in the total market. How is it possible for a company to increase its market share in every market in which it operates and still suffer from a declining share of the total market? The answer to this question lies in the fact that there were significant shifts in the structure of the total market.

If we examine the changing structure of the

cigarette market we can easily see the reason for the paradoxical behavior of American Tobacco's share of the market in 1952, 1955, 1956, and 1957. In 1952 the company was getting a smaller share of a submarket that was winning a larger share of the total market; therefore, they recorded a larger share of the total market. In 1955, 1956, and 1957 the company captured a significantly larger share of two declining submarkets (regular and king-size cigarettes) and only a moderately increasing share of the expanding filter-tip submarket; the net effect was a decrease in its share of the total market.

In general, the 1951-1959 trend in the net changes in American Tobacco's share of the total cigarette market reflects the company's product development strategy more than its marketing (that is, advertising and sales promotion) strategies. The company was a leader in king-size cigarettes and benefited from the consumer's shift to king-size cigarettes which occurred from 1950 through 1954. The company failed to exploit the filter-tip cigarette markets, which gained increased importance beginning in 1955, and the mentholated cigarette market, which began to grow relatively rapidly in 1956.

This example illustrates in concrete terms the importance of developing a planning system in the proper level of aggregation. It is clear that the diagnostic value of analyzing the single share of the market statistic was limited, if not completely misleading. The analysis of individual submarket shares and the changes in the composition of the total market, however, offers valuable insights useful in appraising the company's true market position. The use of computers and mechanized planning models makes it practical to consider the operations of a company in a relatively fine level of detail. Before high-speed electronic computers were widely available it was not practical to build a large-scale planning model incorporating the degree of detail (that is, level of disaggregation) necessary to answer the kinds of questions that must be answered to develop a corporate strategy. But this bottleneck has been broken. With the use of modern computers, it is both feasible and practical to consider the interactions and interrelationships among thousands of variables.

The strategic planning system must also consider a fourth requirement: it must provide a basis for understanding (and defining) the interrelationships between interrelated activities. The importance of this point is obvious. For purposes of analysis, any business can be regarded as a collection of activities, each consuming inputs (from other activities) and producing outputs. The planning model will represent a mathematical formulation of these input-output relationships. One of the greatest values of the strategic planning system is that the development of the planning model itself requires careful analysis and consideration of the interconnections between the various factors that contribute to the company's profits. In building the planning model we have an unusual opportunity to review and evaluate all aspects of the company's operations. Since the model is formulated mathematically, there is little room for vague or "fuzzy" thinking. As the model is being developed, many important questions that would otherwise be avoided must be answered. As these questions are answered, management will gain new insights regarding many of the more subtle factors that influence the company's profits.

The final basic need that must be recognized in developing a strategic planning system is the need to recognize and understand timing-patterns; that is, the time lags and lead times that will determine the ultimate feasibility or success of a venture. Here we are concerned with developing a time-phased schedule of the actions that must take place, or the resources that must be committed, to achieve a desired objective. Time is one of the most important variables in the strategic planning equation. A strategy that does not consider lead times and make proper allowances for time lags will be doomed to failure. As indicated above, every action a business takes must be specified in two dimensions. The action itself must be defined and the timing of this action must be indicated. In addition to knowing what to do, management must know when to do it. The importance of timing is emphasized in management's current interest in PERT, critical path scheduling, and other network analysis planning techniques. Only by understanding the dynamic and temporal inter-

relationships between the factors that determine the ultimate outcome of each strategic decision can we be sure that the actions specified in the company's strategic plan are consistent, feasible, and optimal.

USING THE STRATEGIC PLANNING SYSTEM

In the discussion above we were concerned with some of the specific technical or methodological needs that must be considered in developing a strategic planning system. We might call these needs "design specifications" or "requirements." Consider now the needs of the users of the strategic planning system. How will top management use the strategic planning system? The strategic planning system will provide corporate management with a tool for testing and evaluating decisions involving the major strategic "trade-offs" that must be considered in setting the company's objectives and in developing corporate strategy. The system will assist management in determining the most profitable balance between conflicting objectives. With few exceptions the major problems concerning top management fall into the following five broad categories:

1. Short-term profits versus long-term growth.
2. Profit margin versus competitive position.
3. Direct sales effort versus market development effort.
4. Penetration of existing markets versus the development of new markets.
5. Related versus unrelated new opportunities as a source of long-term growth.

The long-term success of any large enterprise is crucially dependent on top management's ability to establish corporate policies and objectives and develop growth strategies that reflect the most favorable combinations of these trade-offs.

The most important and difficult strategic decisions that top management must make are those involving the trade-offs between protecting an existing profit rate (or attaining a desired profit rate) and maintaining the company's competitive position. This is particularly true for companies which enjoy a significantly higher- or

lower-than-average profit rate as compared with their competitors or the industry as a whole. A company with a high profit rate is faced with the problem of protecting it in the face of competition. A company with a low profit rate is faced with the problem of improving it without seriously weakening its competitive position. To be fully meaningful, any analysis of the trade-off between profit margin and competitive position should be carried out on an individual product basis, a product group basis (to include competitive or substitute products), or a market sector basis.

Decisions involving the trade-offs between direct sales effort and market development effort are particularly important to companies which are engaged in basic materials or new product industries. How can a company maximize its sales and profits? Is it more profitable to enlarge the sales force and increase promotional effort or to engage in research programs designed to find new and additional uses for the company's products? This point will be discussed more fully below. In general, we are concerned with establishing the most profitable balance between those expenditures designed to convert a prospective buyer of the company's products into a customer, and those expenditures that are designed to increase the number of prospective buyers by finding new uses for the product.

The last two strategic trade-offs are closely related. A company may achieve a desired growth objective by continuing to penetrate its existing markets or by developing new markets. If a company decides to develop new markets, the question of the relationship between the new product and the company's existing products becomes important. Top management must decide on a strategy regarding unrelated new market opportunities. For example, at what point will the company not consider a new opportunity because it is too unrelated to the company's existing products?

THE TOTAL CORPORATE PLANNING SYSTEM

We shall discuss some important aspects of new product strategies when we consider the nature of a corporate alternative evaluation and strategic planning model. Before we discuss this

model, however, it is useful to consider the total corporate planning system.

A complete corporate planning system will consist of five basic functional elements: (1) the corporate alternative evaluation and strategic planning model; (2) a problem analysis, model selection, and activity level generator subsystem; (3) an activity level to transaction input converter subsystem; (4) a transaction subsystem; and (5) an output analysis and display subsystem. In actual practice these elements may be combined and the functions of one or more subsystems can be combined into a single subsystem. Consider each of the functional elements and their interrelations.

The corporate alternative evaluation and strategic planning model is the heart of the corporate planning system. This corporate model will consist of a set of interrelated submodels. The number or types of submodels required in any specific corporate model will depend on the nature of the company's business and its planning philosophy. In general, these submodels will describe one or more of five basic types of relationships. The relationships are as follows: (1) the structure of the company's operating environments (market potential, market maturity, nature and degree of competition, and the like); (2) input-output or resource expenditure productivity relationships (production functions, market and product development requirement functions, and the like); (3) competitive interactions (competitive exchange rate relationships and the like); (4) timing response relationships (the relationship between the time, shape, and intensity of an outcome and the level and rate of input resources expended); and (5) the implications of alternative timing decisions (the impact of the timing patterns of different actions—new product announcement dates, timing of advertising and marketing campaigns, etc.—on the company's ultimate revenues and profits).

The purpose of the corporate planning system is to solve planning problems of the types discussed above. When these problems arise, they will be formulated in the language of management and not in the language of the corporate planning model. Often these problems will be stated in a very loose and imprecise manner.

The problem analysis, model selection, and activity level generator subsystem must be designed to analyze the problem, formulate it in terms of the variables included in the planning model, and select that combination of submodels that may be combined to generate a solution. In general, the solution of a planning problem will involve finding the answers to three interrelated questions: (1) Should a given action be taken? (2) If the action is to be taken, when should it be taken? (3) What resources should be committed to the action? These questions must be answered relative to the objective the company expects or desires to achieve by taking the proposed action.

The ultimate measure of the attractiveness of any action the company is considering must be expressed in financial or accounting terms: How will the proposed action affect the company's profit rate or rate of return on investment? What impact will this action have on the company's profit and loss (income and expense) statement or balance sheet? The output of the problem analysis, model selection, and activity level generator subsystem may often be measured in terms of "physical" activity levels that are not comparable with the "standard" inputs required in the company's financial or accounting transaction recording system. If this is the case, an *activity level to transaction input converter subsystem* must be developed. This is a translation subsystem designed to convert "physical activity" inputs into "standard financial" inputs for the transaction subsystem discussed below.

To be useful as a practical working tool, the corporate planning system must provide management with analyses, evaluations, and recommendations regarding possible action alternatives expressed in terms that are both familiar and acceptable as part of the company's normal decision-making apparatus. Any projections of the results that might be expected as a result of the action being considered must be expressed or measured in terms of those income statement, balance sheet, and related analytical data that management normally considers in evaluating any action recommendation. Ideally, the system should provide a basis for rapidly preparing a series of "before and after" income statement,

balance sheet, and operating ratio projections that can be compared, thereby providing an objective, factual basis for decision. *The transaction subsystem*, therefore, must be designed to provide the capability for quickly projecting the impact of any contemplated action on the company's income statement, balance sheet, and operating ratios. The transaction subsystem will represent a mechanized miniature aggregate version of the company's accounting and financial measurement systems.

The output analysis and display subsystem becomes important when many different possible alternatives are being considered. In developing a corporate strategy it would not be unusual to consider several hundred or even several thousand different possibilities. (Indeed, in the analysis of many complicated problems involving national defense strategy and the selection of weapon systems, Department of Defense analysts have successfully employed computers to examine and evaluate tens of millions of possibilities.) In considering even a relatively few important strategic trade-offs it would not be difficult to generate enough raw computer output to swamp even the most enthusiastic management. The output analysis and display subsystem must be designed to perform an analysis and synthesis function by "digesting" the output of the transaction subsystem and displaying this output in a form that will provide management with the most useful and meaningful analytical basis for decision.

THE CORPORATE ALTERNATIVE EVALUATION AND STRATEGIC PLANNING MODEL

The corporate planning system was designed to provide management with an analytical basis for solving strategic planning problems. As discussed above, the heart of the planning system is a series of submodels which are combined to develop the *corporate alternative evaluation and strategic planning model*. I would like to conclude this paper with a brief discussion of the elements of this model, since the preparation of its required building blocks represents the major contribution market research can make to the top management planning process.

The strategic planning model can take many

forms. A full discussion of the many different submodels that might be combined to develop a specific corporate model is beyond the scope of this paper; therefore, I will discuss the strategic planning model in its most general form. The basic relationships described below represent a system that can be adapted to almost any strategic planning problem. Consider first the kinds of data required to build the planning model. The construction of a strategic planning model will require the development of seven sets of basic building blocks. These building blocks are as follows:

1. Total market potential or economic environment planning factors.
2. Market development (product coverage and scope) planning factors and resource expenditure productivity relationships.
3. Market realization (or penetration) rate planning factors and resource expenditure productivity relationships.
4. Share of market and competitive impact planning factors and resource expenditure productivity relationships.
5. Price structure and pricing policy planning factors and market response (price elasticity) relationships.
6. Fixed or overhead cost planning factors and resource (or investment) requirement relationships.
7. Variable cost planning factors, production functions, productivity relationships, and resource requirement relationships.

These building blocks may be combined to answer the questions that are fundamental to the strategic planning process. In developing a corporate or divisional growth and profit strategy, seven basic questions must be answered:

1. What is the economic opportunity?
2. What is the salable market potential?
3. What are total industry sales?
4. What are company unit or constant dollar sales?
5. What are company actual dollar sales?
6. What are company costs and expenses?
7. What are company profits?

It will be noted that the first five questions, involving the factors which will determine the company's revenue or sales volume, can be an-

swered by combining the first five building blocks. It will also be noted that each of these building blocks requires data that must be supplied by the company's market research or market planning activities. To answer the sixth question, cost and expense data from the company's financial departments are required. The last question can be answered by merely combining the answers to questions five and six.

Given the structure and organization of the economy and the level of economic activity, business opportunities exist independently of the company's ability to take advantage of (or awareness of) these opportunities. The first question that must be answered in developing a corporate strategy or establishing long-term objectives is, "What are the economic opportunities for the company?" To answer this question, an estimate of the total market potential for all products and services that might logically fit into the company's product scope must be developed. This estimate should include *all* products and services, even those that are not presently included in the company's existing or planned product line. It is important to recognize the distinction between market potential and total industry sales. A market potential estimate is a conditional "if-then" statement. It should be constructed by answering the question, "What *would* total industry sales be *if* every possible prospect for the product were to become a user, and *if* all users of the product were to become maximum or optimum users?" The total market potential estimate can be regarded as an estimate of "potential potential." It is important to consider an all-inclusive definition for total market potential to provide management with an estimate of the extent to which the company's salable market potential can be increased through new product development or by adding new products through merger or acquisition. The total market potential estimate will also provide a basis for estimating the extent to which the company's product scope might have to be expanded to attain a desired long-term growth objective.

The second question that must be answered is, "What is the company's salable market potential?" That is, given the company's *actual* products and services, what is its "real" market

potential? While total market potential considers all products and services the company *could* market (consistent with the constraints imposed by its product scope), salable market potential considers only those products actually *included* in the company's product lines. The market development rate is a measure of the extent to which the company has developed its market by including all acceptable products in its actual product line. If the company has included all possible products in its actual product line, its market development rate would be 1.0, or 100 percent, and salable market potential would equal total market potential. By definition, salable market potential is equal to the product of total market potential multiplied by the market development rate. The company can increase its market development rate by adding new products to its product line.

The third question is, "What will total industry sales be?" Once the company's salable market potential has been estimated, a total industry sales estimate can be derived by multiplying salable market potential by an appropriate market realization (or penetration) rate. The market realization rate may be considered to be an index of market maturity measuring the extent to which all prospects for the products have entered the market and all users of the products have attained a full usage rate. If the market is completely developed, the market realization rate will be 1.0, or 100 percent, and total industry sales will be equal to salable market potential. In the case of new products, there will be a low market realization rate indicating that only a small fraction of potential users have entered the market. Any action the company takes to convert nonusers into users or to increase the usage rate of existing users will increase the market realization rate.

The fourth question is, "What will the company's unit or constant dollar sales be?" Company sales will represent a fraction of total industry sales. The competitive impact factor will measure the company's share of the market. Company sales will represent the product of total industry sales multiplied by the competitive impact factor. Any action the company takes to increase its share of the market will improve its competitive impact factor. Any actions com-

petition takes to increase its share of the market will weaken the company's competitive impact factor.

One of the most important instruments a company can employ in developing its corporate strategies is price competition. The company's prices relative to competitor prices for competing products or the prices of substitute products will determine the company's market share (competitive impact factor) and the rate of product acceptance (market realization rate). The company's pricing strategy will also determine its actual dollar volume, given its unit (or constant dollar) sales. The fifth question is, "What will the company's actual dollar sales be?" I have included this relationship and expressed the first four relationships in physical or constant dollar terms to provide an explicit basis for the consideration of the implications of pricing strategies.

The final questions to be answered are, "What will the company's total costs and expenses be?" and, "What will the company's profits be?" To answer the first question a set of cost and expense factors must be developed covering all phases of the company's operations. It is useful to consider both variable cost factors, which include those costs and expenses that are dependent on the company's sales volume, and fixed or overhead cost factors, which include those costs and expenses that are independent of sales volume. For the purposes of developing a strategic planning model, it is useful to consider costs and expenses classified according to *objective categories* rather than conventional income statement accounts—that is, all cost and expense planning factors and relationships should be summarized and classified according to the objective the company expects to achieve as a result of the resource commitment rather than in some more conventional accounting record summary. Since the strategic plan is concerned with determining the most profitable set of strategic trade-offs, all cost and expenditure data must be classified into objective categories that match the trade-offs being considered. For example, marketing expenses can be classified into those expenses that are required to maintain or attain a given share of market position; expenses (customer development) designed to improve the

company's market realization rate; or expenses intended to open new markets, thereby improving the company's market development rate. Similarly, product development expenses might be classified into those expenditures required to keep the company's existing product lines competitive; to add new products to the product line, thereby improving the company's market development rate; or to develop improved versions of existing products to attract nonusers, thereby improving the company's market realization rate. The success of the strategic planning system will critically depend on the ingenuity of the company's financial personnel in developing cost and expense objective category data. Once a projection of the total revenue and costs and expenses is developed, the final profit estimate may be derived by subtraction.

The ultimate success of any strategic planning program will depend on the ability of the company's market research and market planning personnel to develop the various market structure data necessary to relate the company to the industry and the industry to the economy, for market potential estimates provide the basic structural framework for strategic planning. Consider the fundamental choices available to management. Any corporate strategy must place first priority on protecting the company's existing market position or improving this position by capturing some of its competitors' share of market. The second priority must involve programs designed to improve the company's market realization rate by converting unsold market potential into sales. The third priority is to increase the company's salable market potential by developing the new products necessary to convert undeveloped market potential into salable market potential. The fourth priority involves changing the company's product or service scope to increase the company's total market potential. Management must determine the most profitable trade-offs in setting the company's competitive impact factor, market realization rate, and market development rate. These represent *all* of the actions the company can take in the marketplace. Through new product development, merger, or acquisition the company can change the markets in which it operates; but, once its markets are determined, only the choices out-

lined above exist. The other side of the profit coin involves skillful control of costs and expenses. The importance of such control should not be minimized. Each of the company's discretionary expenditures should be carefully reviewed to determine its exact contribution to the company's ultimate profits. Every discretionary cost or expense should be analyzed to determine its impact on the market development rate, the market realization rate, and the competitive impact factor; its contribution to increasing total market potential (by broadening the company's product scope); or its attractiveness as a cost and expense reduction investment.

Rapid changes in the business environment; new technologies creating opportunities; new competition at home and abroad; the high cost of undertaking new ventures; the large investments and long lead times necessary to enter new markets; increasing labor costs and severe price

competition; and the increasing complexity of business operations—all these factors place a high premium on thinking ahead, planning ahead, and staying ahead. The development of a meaningful strategic planning program is one of the greatest challenges facing corporate management and their professional staffs in the next decade. What I have tried to do is to give some insight into a problem that plagues top managers and present the problem in a fashion that would make the possible applications of the computer and use of the management information system fairly obvious. One of the interesting developments that I see for the future—five, ten, or even fifteen years from now—is that, as management information systems develop and as computers provide logical means for management to examine and consider alternatives, probably for the first time since the industrial revolution managers are going to manage.

INFORMATION SYSTEMS FOR BETTER MANAGEMENT OF FINANCIAL RESOURCES •

1. Areas for Financial Decisions in a Make-and-Sell Business

KENNETH E. TIGGES

THE OLD SAYING, "NOW YOU SEE IT, NOW YOU DON'T," typifies the character of the financial resources of a dynamic firm. While finances are one of the most critical resources of a firm, they are also one of the most elusive and changing in form. This is not by accident. A business must constantly convert these resources as rapidly as possible into goods or services with more profit potential characteristics than the financial resources themselves. It is this fluid condition which blurs the image of financial resources and

makes them difficult to discuss without encompassing the entire scope of corporate operations.

THE FINANCIAL CYCLE

Even though the financial resources of a company are in an almost continuous state of change, we can take a still-life view of the com-

KENNETH E. TIGGES is Corporate Comptroller, Owens-Illinois, Inc., Toledo, Ohio.

position of these resources at a moment in time—an action analogous to stopping a motion picture on one particular frame so that it can be studied more thoroughly. In the financial area this is accomplished through the means of a balance sheet. Under these static conditions we can identify the liquid resources of the company as cash and those short-term securities which can be readily converted to cash.

However, just as the stopped motion picture portrays only one point in time, so does the cash and securities figure on the balance sheet provide an incomplete view of our financial resources. The flows of financial resources into, through, and out of the firm can more readily be identified in the cash flow statements and statements of source and application of funds.

The flows of funds into the company normally come from two types of sources. The first source, hopefully a continuous one, is our customers who are induced to provide financial resources in payment for the goods and services received. The second can be a one-time source or, at best, periodic in the form of investors who provide financial resources in exchange for legal documents of ownership or indebtedness of the firm, for which they expect an appropriate return.

The uses of financial resources are many and varied. For illustrative purposes, the primary classifications can be listed in rather elementary form. Financial resources become "capitalized" into the more permanent facilities of the business; they are used to purchase materials for conversion into higher-value products; and they are used to compensate the workers and managers of the business. The combination of the facility, material, and manpower resources generates the goods and services, or the products, of the firm. A significant portion of the resources is used to satisfy the federal, state, and local requirements for taxation. And, finally, funds must be provided for interest and dividend payments to the investors, for the repayment of loans, and for further expansion.

The financial resource cycle becomes complete—in computer terminology, "the loop is closed"—when the products are sold to the cus-

tomers, a profit is generated, and the interest and dividend returns are made to the investors. The same investors do not necessarily reinvest in the firm on the next cycle.

THE DECISION POINTS FOR FINANCIAL RESOURCES

Each of the sources of supply, holdings of liquid assets, and uses of financial resources becomes a focal point for decisions in the management of financial resources. Therefore, they also become the key areas for emphasis in our information systems if these systems are to aid managers in making the best decisions for most effective management of the resources.

1. Adequacy of financial resources. The most crucial question which the financial officer faces is whether the financial resources will be adequate for the future needs of the company. The answer to this question lies in the critical balancing point of future requirements versus future availability and can only be pried loose with the tools of planning and forecasting. Again, the total spectrum of the business must be drawn together, since it is only through a good operating plan which reflects—as accurately as the future can be reflected—the planned activities of the company so that a financial interpretation of its cash needs can be made. Once the needs are established, the financial officer must then interpret the future of the financial marketplace so as to avail himself of the additional resources needed at the best possible price from the most advantageous source.

Financial resources—be they from new shareholders or from lending agencies—have a cost, just as do material and labor. To obtain the resources too soon can result in a penalty; to wait too long can mean entering the financial marketplace at a time when new debt or capital bears a high cost.

Let me state again that the answers to these questions cannot be generated simply within the organizational confines of the financial officer; rather, they must be fed in from the vast network of information systems and management decisions touching on every facet of the business.

The first concern in the management of financial resources is to make certain that these resources continue to flow into the company. Without this input the entire mechanism will grind rapidly to a halt.

2. *Customer sources of finances.* The uniformity and velocity of the flow of financial resources from the customers are highly dependent upon the nature of the business and the size of the firm. The selection of the markets and the cultivation of customer relationships normally are marketing responsibilities. However, the profitability of markets and even of particular customers has a definite impact upon the financial resources of the firm and their management.

The method of payment and the terms under which sales are arranged are of immediate concern to the management of financial resources. Credit policies which are so conservative as to avoid any losses due to bad credit may well result in turning away profitable business. Contrarily, if credit terms are too liberal and allow extended payment periods, the financial resources of your firm can be diverted to the customer, permitting him to operate on your capital. Information systems should provide the data to aid marketing personnel in selective selling as well as to predict the timing of cash flows from the sales.

3. *Investor sources of finances.* The flows of financial resources from investor sources are usually more durable and more predictable than those from the customer sources. However, in the company whose future needs for expansion cannot be met out of retained earnings, additional long-term capital resources will have to be solicited. This can be accomplished through borrowing or through the issuance of additional stock. Whichever course is taken, the decision is worthy of most careful deliberation, since it will have lasting effects.

If the decision is to borrow, the time limit for the loan must be determined, the type of loan must be selected, and the source of the loan must be chosen. If the stock alternative is selected, there explodes a further range of possibilities. In either case, accurate forecasts of future earnings and cash flows are essential so that management can be assured that funds will

be available for the repayment of loans or, in the case of a stock issue, that the values of present shareholders will not be diluted.

4. *Finances for facilities.* As mentioned earlier, the uses for financial resources range from investments in physical structures (which long may stand as evidence of the expenditure) to the purchase of services or the payment of taxes, where the benefits are of a much less tangible nature. On the more durable end of the spectrum, financial resources are converted into such facilities as land, buildings, and equipment, where there is usually a gradual deterioration.

Expenditures for facilities have a twofold effect on financial resources. The first and most obvious is the actual outflow of funds for new facilities and for the maintenance and improvement of existing facilities. Here, of course, the financial manager must be assured that control procedures are in effect which will allow him to forecast accurately the timing of the expenditures, as well as provide information on changes in plans which may result in overexpenditures. The second area, depreciation, is slightly more elusive. The book charge for depreciation is, of course, merely a method of spreading the cost of an asset over its functional life. Depreciation for tax purposes, however, may represent an opportunity to provide additional cash flow to the corporation through the use of the most advantageous procedure for income tax purposes, even though the manager may not wish to use the same method for financial reporting purposes. The advent of accelerated depreciation for income tax purposes in 1954 and the guideline depreciation procedures authorized in 1962 have both complicated the reporting of depreciation for income tax purposes and provided an opportunity for added cash flows to the corporation.

Since capital expenditure programs can be a serious drain on the financial resources of a company, particularly during a period of rapid expansion, one of the valuable services which a financial manager can provide is the establishment of good evaluation techniques regarding the profitability of proposed ventures. Some of the new mathematical techniques and the advent

of risk analysis which computer programs facilitate allow managers to more accurately predict revenues or savings from such expenditures and their long-range effect on the financial resources of the corporation.

Since the maintenance of existing facilities and equipment represents a heavy recurring cost, there is great opportunity in the area of repair-or-replace studies for cash savings to a company. The techniques in this area regrettably are still somewhat crude, but advances are being made.

5. *Finances for materials.* The usage and mix of materials used are strictly operating decisions. The calculated cost, both anticipated and actual, are matters for financial concern, as is the expected turnover. These are the areas where cost accounting and budgeting have flourished. An area for further financial consideration is the analysis of whether the materials or sub-assemblies can more economically be produced or bought.

6. *Finances for manpower.* The management of personnel resources is the concern of every supervisory position. The managers of financial resources are concerned primarily with the costs of wages, salaries, fringe benefits, and purchased services. An area where there must be more concern and more effort by financial managers is in the development of means for measuring the value of salaried personnel effort. The next step would be that of predetermining the value of effort. Such techniques would be helpful particularly in deciding whether or not to undertake such projects as systems design and research and engineering.

7. *Finances for products.* The decision point for products falls broadly into two responsibility areas. The area of determining the market potential for a particular item and for ascertaining the effort which will be necessary to penetrate that market is for the most part a responsibility of the marketing organization. However, when it comes to predicting and measuring the profitability of the item, many organizations may take part. The costs of doing business—whether directly a part of the product, indirectly related to the product, or just general overhead—must

be calculated and allocated to the product. This is usually an accounting function. The margin decision (what the product can be sold for) is a highly sensitive and critical decision involving the management of both the marketing and financial functions.

8. *Finances for taxes.* Taxation is a decision area of vital concern to the management of financial resources. The use of corporate funds for payment of taxes based on income, property holding, employment, and numerous other bases requires specialized management and equally specialized information systems. In fact, the emphasis on reporting for tax purposes has in the past often taken on such proportions as to dominate the information system structure. For example, many companies adopted the most advantageous tax procedure for financial reporting even though management and shareholder reporting purposes would have been better served by another procedure. The advent of the computer with its capacity for handling great volumes of data in dual systems is allowing the separation of these considerations.

9. *Return to investors.* The final area for our consideration in the management of financial resources—although certainly not last in terms of actual concern or importance—is that of return to the investors, whether they be owners or creditors. Here, the need is first to meet the legal commitments for interest on borrowings and the dividends on preferred stock. It is further necessary to determine the dividends which should be declared on common stock to keep it sufficiently attractive to investors. Balanced against the earnings to be paid out to investors must be a consideration of that which should be retained in the company for future growth. Finally, provision must be made for the repayment of principal to lenders as well as the retirement of preferred stock.

These nine decision points comprise the major areas of concern in the management of financial resources. They identify focal points for concentration of information systems if the systems are to be of greatest value in the management of financial resources.

II. Information Systems for Financial Resources

THOMAS H. BROWNING

DURING THE PAST SEVERAL YEARS THERE have been significant advances in information systems to support the decision-making process relating to financial resources. Many of these systems have been computer-based. The quantity and quality of these systems have been relatively high and have made a favorable impact on financial management in our major industrial institutions. In this respect, the progress of Owens-Illinois is fairly representative of the situation in industry today. Some companies have made greater penetration into certain areas and on total balance some are ahead of us, but we are not far behind. I will discuss here the criteria established in the preceding paper to show how Owens-Illinois has faced the opportunities and problems encountered in the financial decision-making process.

1. *Availability of financial resources.* The first decision point is concerned with the adequacy of financial resources to meet future needs. It is ironic that this is the last point to get an answer; to be able to answer this question with certainty would necessitate a completely integrated financial reporting and forecasting system covering all phases of the business. This we don't have, and neither do many other firms.

The nearest we can approach to this information requirement is with a corporate general accounting system which is computer-based. This is a financial system which provides information for compilation of the usual financial statements plus much of the information needed for management of financial resources. The information generated by this system has reduced the time lapse in the preparation of information, and it does provide a factual basis from which to launch our financial projections.

2. *Customer sources of finances.* Information concerning input to our financial resources through the customer channel has been greatly

improved through a computerized marketing and profitability system. This system provides basic sales information, both unit and dollar, for a major segment of our business in a much shortened time period. It combines cost information with sales information to identify sales margins by customer, with a breakdown by product lines. This information enables us to identify sales performance and profit contribution at any level of the sales organization. It enables better decisions on the allocation of costs. Most important, it provides valuable information on the profitability of various marketing areas as a basis for better direction of marketing effort and improved generation of financial resources.

3. *Investor sources of finances.* Decision point three is concerned with the selection of investors to encourage to be suppliers of financial resources. To date, we do not have any computer-based systems which directly generate the information necessary for these decisions. However, the variety of information systems outlined here provides much of the information which must be used by managers in determining the mode of financing new capital expansions.

4. *Information for uses of financial resources.* As indicated by Kenneth Tigges in the preceding paper, the use of financial resources for facilities can be a heavy drain on the capital of any company. The financial considerations are of two types. The first is concerned with actual expenditure for new facilities and for maintenance of existing ones. The second decision is concerned with the most effective means of calculating the depreciation of the investment.

A computer program to aid in the analysis of proposed expenditures for new facilities or

THOMAS H. BROWNING is Corporate Manager, Data Processing Administration, Owens-Illinois, Inc., Toledo, Ohio.

new products has been developed by the comptroller's staff at Owens-Illinois. This program calculates the usual discounted cash flow information and applies factors of probability to the calculations. The result is not a single discounted cash flow figure. It produces a range of possible rates of return and their probabilities of occurrence. Such a tool can aid managers in evaluating the risks involved in any proposed expenditure.

Information reporting the actual expenditure on new facilities under construction is available out of our property accounting system and enables better decisions on the expenditure of funds. This system further calculates depreciation on the capitalized items according to the methods designated for book and for tax purposes. This system provides information to financial management to aid them by projecting cash flows from tax depreciation.

5. *Computerized measurement and reporting of basic materials.* Some of the basic materials which go into our products are sand for the manufacture of glass and paperboard for the manufacture of shipping containers. Computerized measurement and reporting of glass batch materials are being introduced into our glass plants as a means of more precise material control and for more accurate management of the inventory of raw materials. Nearly all our company's paperboard inventory and usage are reported under a nationwide, computerized, roll stock control system. This information provides for better allocation of financial resources to this key material resource.

6. *Information systems and personnel resources.* Our company, like most companies, cut its computer teeth on hourly and salary payroll applications and then developed substantial computer programs to help control efficiency and costs. The effects of these employee systems on financial resources have been most significant in those manufacturing locations where the costs are more variable.

7. *Product marketing and inventory management.* This decision point is concerned with which products to market, whether to make or buy, and the efficient management of inventories. The marketing and profitability system described previously generates information helpful in de-

termining which products to market. Considerable progress also has been made in the management of finished goods inventory for more than 60,000 stock items. This control begins in the order processing system which consists of a transmission network linking 130 company locations. Minimal sales order information originating in the sales branches is transmitted to a computer center where it is exploded into full sales and factory orders. Inquiries are made to determine whether stock items are available. As goods are manufactured, stock record quantities are automatically increased. As goods are shipped, the invoices are automatically prepared and stock level records are reduced.

The impact of these systems on our financial resources is in the rapid response of the order preparation and invoicing system. It serves to speed up the flow of resources through the system in terms of the time it takes to enter an order, release the shipment, and bill for the goods. Less of our financial resources needs to be tied up in the order cycle and finished goods inventory.

8. *Automatic calculation of taxes.* The general accounting system described previously in this paper calculates automatically many state taxes and our Federal income tax. Taxes based on number of employees and employees' wages are calculated as part of the computerized payroll systems.

9. *Payment of interest and dividends to the investors.* Here there is a share-owner system which handles stock transfers, proxies, dividend payments, and other matters that support the share-owners' investments.

* * *

It is apparent that our company is beginning to close in on many of the systems which provide information necessary for the management of financial resources. And, as I pointed out earlier, this progress is probably typical of firms which are moving ahead with their computerized systems.

At the same time, it must be apparent that most of these systems are designed to be of help on the operating level for both financial and nonfinancial resources and do not respond auto-

pattern: A customer places an order with his broker to buy or sell securities on the basis of quotations obtained by the broker. (In addition to the data about the last transaction, the quotation system has a requirement to know the volume in that stock for the day and what the trend has been today, not only in the subject stock, but also in the market as a whole.) The order is transmitted to the floor of the Exchange by one of several means, none of which is apropos to this discussion. There, a floor broker and a specialist enter into a transaction to execute the order for the customer.

There are two classes of data in the public domain with respect to securities transactions: real-time and historical. (Market surveillance requirements are met by interrelating all of the real-time and historical data in specific modes.) In the quotation data are the bid-and-asked quotations and the price of the last sale in that security. And it is necessary that the data are current, because the general public is making decisions to buy or sell securities in a continuous auction market based on these data.

The historical data concern previous activities of both today and yesterday. They include the price of the last sale today; the net change from yesterday's closing price; today's volume, open, high, low; and, in some instances, time from the last sale. Although referred to as historical data, they must also be readily available because a person buying a security should base his decision on a depth of knowledge about his purchase and should know something of the history of his stock in today's market.

Until 1964 the quotation service was supplied by a battery of more than 100 telephone quotation clerks located in the Exchange building. Quotations were sent via pneumatic tube to a series of operator positions, and some of the clerks physically changed the figures for each of the listed securities on large display panels. Another group of clerks monitored the display and answered direct-line inquiries from each brokerage office. The broker would call on his direct line and ask for information about the stock in which he was interested, and the clerk would recite the information over the line and disconnect. If he wanted the information again

or did not get it, the broker would have to call back. Through this system, it was possible only to get the bid-and-asked and a last-sale price that was probably stale because the clerks could not post the quotations and the last-sale prices quickly enough. It was clear back in 1960, and particularly in 1961, that a new service would have to be offered. After discussions with suppliers, the Exchange decided to proceed with what was then known as The Teleregister Corporation to develop a voice quotation system.

That system became known as Am-Quote. Its vocabulary was established at 64 characters or words. This was a little tight, but it was felt that more than satisfactory service could be supplied. The response time was first established at 400 milliseconds per character, but it was moved closer to 300 milliseconds to meet the needs of brokers for a more rapid delivery.

By dialing Am-Quote, a broker receives the bid, offer, last, net change, volume, open, high, low, and time for any listed security. The information, which is stored in the stock record of the telefile computer, is written onto a drum. Each telephone line terminates on an individual channel on the drum and, if the broker were to miss this on the first try, he could continue to listen to this data until he got the information requested.

It was felt, when this system was designed, that the broker could not afford to receive a busy signal. If he had a customer, he wanted immediate answers. Consequently, there were no concentrators installed in this system. Good telephone practice, of course, would have called for the use of concentrators; but the very time that a broker really needs a fast response—that is, when the market is active—is the time when everybody else needs a fast response. So, regardless of the number of telephone inquiries, there is never a busy signal on Am-Quote. The system was designed to handle 72,000 calls an hour and can be expanded.

An essential part of the overall quotation system is the quality of the data; and, if no quote is available, it is necessary to tell the inquirer why. There are a total of six reasons why there may be no quote; for simplicity's sake, we number them one through six. The term

"none one" indicates that no opening quote has been made by the specialist. "None two" indicates that the stock is very active and that it is impractical to submit quotes that would be up-to-date enough to base an order on. In this case, the salesman must contact his floor broker to get the latest quote from the specialist at the post. "None three" means the quote is being checked. Every time a sale is made, the Am-Quote computer checks to see if the price is within certain predetermined tolerances. If the last-sale price is outside the range of the quotation currently in the stock record, the quotation is purged from the active system and a message is sent to the control center. Here, the challenge is interpreted and corrective action initiated. If an error took place in the input center, a correction message is entered into the system. If the stock needs a new quote, the specialist is notified and he submits a new quote. In the meantime, however, the Am-Quote response reports "none three." "None four" indicates that trading is temporarily halted. This condition may be due to an influx of orders or a pending announcement by the company of considerable significance to the market. "None five" indicates that a stock is suspended, and "none six" means a delayed opening.

The error correction and system monitoring requires a staff of six clerks at the Exchange input center, in addition to the personnel operating the computer at Bunker-Ramo's Tele-Center in lower Manhattan. A staff of more than 40 input operators and clerks is required to maintain the input and filing operations for the Am-Quote system. Although this is a considerable reduction from the 100 clerks employed prior to cut-over, the workload has been expanded to handle trading of five million to eight million shares a day, if necessary. A new service is also provided since the source data are readily available: the sale report slip is filed immediately after transmission, so that a broker can determine the exact time of the trade if he calls a special number.

While the Am-Quote system was developed to function within the context of Exchange trading rules, S.E.C. requirements, the limitations of electronic equipment, and the method

of trading in an auction market, it has not always been possible to enforce some of the rules that were part of the requirement criteria for the development of the system. For instance, the computer has been programmed to print out at 10:05 A.M. in the control center a listing of all stocks on which no opening quote has been received. Sometimes, this list is excessively long and each "no quote" requires action by the correction clerks. In an active market of four million shares a day, it is necessary to follow the rules or the system may bog down. On some days we are required to get relief from the rules in order to maintain the system in readiness. So, if the system is developed to meet rules, it is advisable to be sure that the rules can, and will, be followed when the system becomes operational.

Am-Quote is used primarily by the managing partners and senior people in the member firms; by the registered representatives, or customer's men; and by personnel in the back office. Throughout the Exchange, there are Am-Quote telephones for use by administrative and floor people. There is an Am-Quote phone inside every trading post so that a specialist or his clerk can check the quotation in the stock record to see that his stock is properly quoted. In addition to the 325 direct lines currently installed in broker's offices, there are almost 50 administrative lines within the Exchange. Exchange executives use Am-Quote to check on the operations in the input center. For instance, by checking Am-Quote, it is possible to determine whether or not our tape will start running late or whether additional administrative people are required in the input center to cope with exceptionally high volume. By midday we can usually predict with a surprising degree of accuracy what the total volume will be within one or two hundred thousand shares, merely by listening to the trend and the volume at four successive half-hour periods. For the more volatile stocks, it is possible for the Securities Division, the Surveillance Division, and the Executive Offices to keep an up-to-the-minute running check on each and every stock that is traded and call for corrective action to be taken, if necessary. The Clearing Corporation uses the

information derived by checking on special issues which have split their shares and are being traded on both old and when-issued bases. The last price in extremely active stocks is used for settlement purposes.

This Am-Quote system has been extremely reliable. When outages do occur, they are usually only two to five minutes long. In the almost two years that Am-Quote has been in operation, there has been only one instance of an outage lasting 20 minutes. This particular outage was the failure of the audio response. As soon as the audio was restored, however, the full system was up to date.

Looking back over the history of this program, I think the one thing that we would like to have solved in improving the system was that of inquiry to the system. We would have liked to enter the stock symbol directly instead of converting from the symbol to a four-digit number. This would have reduced the time required for a customer's question to be answered.

Despite this problem, however, Am-Quote has not only satisfied the need for which it was developed—that is, assistance to brokers in the operation of their businesses—but also has been expanded to serve many of the administrative and error-correction functions of the Exchange.

OPTICAL CHARACTER RECOGNITION AS AN INPUT DEVICE •

ROBERT A. GRAY

JUST A COUPLE OF YEARS AGO I THOUGHT optical character recognition (OCR) was the exclusive preserve of the gas and electric utilities, insurance companies, and the credit card companies. The typical sales literature for OCR equipment consistently cited these applications. In the past two years, new equipment and new applications have taken OCR beyond exclusive use by those companies. A growing number of companies are reading sales data directly from cash register tapes, accounting data from journal tapes, premium allowances from coupons, and subscription renewals from postcards. Of even greater impact has been the recent conversion of social security data into a format which can be read by an optical scanner. The list of users is growing by leaps and bounds.

In the past two years, new entrants have been

added to the list of hardware manufacturers. Forms suppliers are also becoming active in the OCR field to capitalize on a growing use of source documents in the OCR machines. In the rather small town of Worcester, Massachusetts, for example, two major forms manufacturers in the past four months have conducted seminars on OCR form design for prospective customers.

Evidently, OCR is a burgeoning field with vast potential. But how does one become involved in its use, and what are the criteria for successful use? Are there options and alternatives? And above all, what are the pitfalls? Perhaps the experience of Thom McAn will help

ROBERT A. GRAY is Director of Systems and EDP, Thom McAn Shoe Company, Worcester, Massachusetts.

other companies to decide whether or not to take the OCR route.

A discussion of OCR at Thom McAn can be conveniently broken down into four sections:

1. The decision for OCR.
2. Selecting the hardware.
3. Designing, testing, and selecting the input document.
4. Preparing personnel to accept OCR.

The decision for OCR. In many ways, this was a decision by default. Thom McAn was looking for a means of gathering from its 850 stores across the nation sales information to form a basis for forecasting and inventory control. The manual systems used for many years provided summarized data only, which are all right for determining how many pairs of children's shoes or how many pairs of sneakers are sold each week; but inventory control relies on specific information and unique identification. In the case of Thom McAn, this means knowing not only the stock number of a shoe but also its width and size. A store with 1,000 different stock numbers would average two widths per stock number and perhaps 12 sizes per width. This means 24,000 separate items for sales reporting and inventory control in each and every store.

To this basic problem are added the facts that our store personnel are sales directed and there is no room on the payroll for a bookkeeper or stock clerk. Thus we needed a sales reporting system that would be:

- Comprehensive enough to provide all required details.
- Accurate enough to provide good inventory control.
- Simple enough to be easily administered in all stores.
- Cheap enough to use so that potential profits would exceed the operating costs.

In our search for this ideal answer, we tried and rejected every possible method of sales reporting yet conceived. One of the methods rejected due to exorbitant cost was to bring all saleschecks (about 500,000 per week) into the home office where the required data would be keypunched and then fed into the computer. From the research for and testing of this method,

we could see the benefit of having a machine to read the saleschecks to eliminate the army of keypunchers required for the job. Unfortunately, we couldn't find a machine to read handwriting directly from the saleschecks. It was when all other methods were rejected that we finally started toying with the idea of revamping our saleschecks to fit a machine that could read the required data.

We were impressed by some of the obvious benefits of an OCR solution:

- The huge volume of paper could be easily handled by a machine at a very low cost.
- The optical salescheck idea would "piggy-back" on the existing system of writing a salescheck.
- Since every sale requires a salescheck, we would be guaranteed a 100 percent reporting base.
- Any cost of saleschecks would be partially offset by the current cost of saleschecks.

Now all we had to do was find a machine to read the saleschecks, design the saleschecks, and see if the idea would work.

Selecting the hardware. At the time we did our initial research, we considered use of the following hardware: (1) Farrington; (2) RCA "Videotape"; (3) IBM Model 1418; (4) Recognition Equipment Inc.; and (5) Rabinow Inc. Since that time, other manufacturers have entered the scene, and today the choice would require much more consideration.

It is not necessary to indicate why we finally decided on the IBM 1418. It is important, however, to know the criteria used in the judgment.

1. *Cost.* Because we did not know whether or not the system would work and we wished to be flexible in a rapidly changing field, it was imperative that we rent the equipment. At the time, none of us was inclined to commit money to a purchase proposition. Further, some machines required more development than we cared to invest in.
2. *Convenience.* During the long period of system testing, which manufacturer would provide us with test time at a

convenient location? This was an important consideration for we had many theories to prove. After all, no one else had put this idea to use in the manner we proposed.

3. *Compatibility.* This was very important because, although some of the hardware would run off-line, most models had to be run on-line with a computer to obtain maximum potential. If the computer was not IBM's, we would need an interface. Most certainly we could not afford another computer in our installation.
4. *Speed.* The machine had to be able to read the saleschecks at sufficient speed so that it wouldn't tie up the computer all day and so that it could handle peak volume without delay. Some of the equipment reviewed was painfully slow and was rejected on this basis alone.
5. *Reliability and support.* The system we envisioned for Thom McAn called for a daily scanning operation with shoe shipments directed by the computer. Any machine breakdown would mean a system failure, a huge cost in wasted warehouse manpower, and sales loss through nonshipment of merchandise. We therefore wanted a measure of hardware "backup" for the breakdowns we knew would occur.

In our evaluation each of these points was extremely valuable. Perhaps another company would need to consider additional factors, but most certainly these five are of great importance.

Designing, testing, and selecting the input document. The salescheck we had in mind was a comprehensive one based on the "mark reading" principle. This method is similar to mark-sensing, but paper is used instead of card stock, no special pencil is needed, and care in marking is less critical because the reading is optical.

Our first salescheck design provided for the marking not only of shoe sales (by stock number, width, and size) but also of sales of hosiery, polish, handbags, and other miscellaneous items together with the prices charged for them. It was a beautiful form! The only trouble was that it had to be three and a half feet long to hold all

the data. We went back to the drawing board and reviewed the basis of the job: We wanted to get sales data for inventory control, but we did not want to perform the store's accounting work. With this thought firmly in mind, we designed a document to report shoe sales by stock number, width, and size—and no more.

All told, we probably designed 30 different saleschecks, but we tested only three. Since we put our final design into use one and a half years ago, only one minor change has been made. The lessons we learned from the test results of the three designs are as follows:

1. *First design* (see Exhibit 1).
 - a. The perforated feeding edge of the document is ragged and tends to jam the machine.
 - b. The double "width" column encourages people to mark both columns, with resulting inconsistency.
 - c. The "size" column is difficult to understand and calls for three distinct marks.
 - d. The "X" marks and black lines create a "busy" pattern that causes poor marking.
2. *Second design* (see Exhibit 2).
 - a. All the former problems were eliminated by this new design.
 - b. Experience was showing that we needed the store number identification and optically readable serial number for proper handling and for error correction routines.
 - c. We found that three-pair sales were not frequent enough to justify passing all the extra paper through the machine.
3. *Final design* (see Exhibit 3).
 - a. It worked!

We thoroughly tested each design in the field; we encouraged every possible criticism and pressured the participants into finding fault. To make sure the test was complete, we actually placed the saleschecks into productive use in our stores. We used 100,000 saleschecks of the first design and 50,000 each of the other two designs. We wrote the programs to read the documents and provide statistical reports on the

A 001465

[illegible]

HOME OFFICE COPY

276520

מלכות

③ Price _____ £6

	AMOUNT	
TOTAL SALE		

STOCK NUMBER		W	SIZE
01	01	01	01
02	02	02	02
03	03	03	03
04	04	04	04
05	05	05	05
06	06	06	06
07	07	07	07
08	08	08	08
09	09	09	09
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
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97	97	97	97
98	98	98	98
99	99	99	99
00	00	00	00

EXHIBIT 1 (TOP) AND EXHIBIT 2 (BOTTOM)

HOME OFFICE COPY

① Thom McAn ②

1921-89582

STOCK NUMBER	W	SIZE
01 01 01 01 01	01	01 01 01
02 02 02 02 02	02	02 02 02
03 03 03 03 03	03	03 03 03
04 04 04 04 04	04	04 04 04
05 05 05 05 05	05	05 05 05
06 06 06 06 06	06	06 06 06
07 07 07 07 07	07	07 07 07
08 08 08 08 08	08	08 08 08
09 09 09 09 09	09	09 09 09

STOCK NUMBER	W	SIZE
01 01 01 01 01	01	01 01 01
02 02 02 02 02	02	02 02 02
03 03 03 03 03	03	03 03 03
04 04 04 04 04	04	04 04 04
05 05 05 05 05	05	05 05 05
06 06 06 06 06	06	06 06 06
07 07 07 07 07	07	07 07 07
08 08 08 08 08	08	08 08 08
09 09 09 09 09	09	09 09 09

MO.	DAY	YR.	SOLD BY
			AMOUNT
①			
②			
D	SALES TAX		
D	EXCISE TAX		
E			
B			
TOTAL SALE			

EXHIBIT 3

results. Perhaps of even more value than the computer statistics were the long hours of study of the marking techniques and habits of our salesmen. Some of our personnel, posing as customers, watched the operating results on the selling floor and questioned the salesmen who waited on them.

The testing and designing was conducted off and on over a nine-month period. By the time it was over, there wasn't much we didn't know about OCR document design. We were satisfied that the final design was the best we could find for the results we wanted. Note that through this entire period of testing Thom McAn had to carry the ball. There was no precedent to follow, the assistance of the hardware suppliers was absolutely zero, and the largest forms manufacturers in the country provided bad advice. In the field of OCR, you'll find that you will often play the part of pioneer.

Preparing personnel to accept OCR saleschecks. There were many people who had to be convinced that the OCR saleschecks would provide the answers Thom McAn wanted. First of all, although our management was very posi-

tive in wanting the OCR results, they wanted the best possible assurance that the system would work. After all, we were asking for an investment of a quarter of a million dollars even before we read the first document—and this type of expenditure calls for something more than blind faith. Our management probably obtained this assurance more from the thoroughness of our test procedures than for any other reason.

At the same time that we conducted the field tests for document design, we also tested out ideas for training our store salesmen to mark the saleschecks properly. This training phase was vital because we just couldn't afford to send training teams to all the stores throughout the country. We didn't have enough people or enough time. Our plans called for implementation of the OCR system in all stores within an eight-week period. It became very evident that installation at the store level had to be the responsibility of each store manager. He had to be prepared to accept this responsibility and we had to make it as easy as possible for him to train his people.

During the test phase, when we introduced

the test into a new area, the district sales manager was brought into the picture because he is responsible for the administration of 15 to 20 stores. Between the district sales manager and the usual employee grapevine, it wasn't long before most stores in the area knew of the testing. We found that, by enlisting the aid of the district manager and judiciously "leaking" news of the test, the introduction of the saleschecks and training of the people was made easier. In the last test phase we installed the system in 12 stores completely by mail—and it worked.

When the time arrived for installation across the entire chain, the sequence of events was as follows:

- April 15—Letter sent to all district managers outlining the entire plan.
- April 30—Letter sent to all store managers outlining the plan.
- May 5—Talk with district managers during their regular annual meeting. Thorough discussion and training.
- May 10—Publicity notice in the company newspaper to all employees.
- May 30—Distribution of "comic book" and managers' manual to all district managers for their prior perusal.
- June 10—Full-scale story in company newspaper with salescheck glued to the front page.
- June 15—Distribution of "comic books" to all stores.
- June 24—Shipment of saleschecks to all stores.
- July 2—Delivery and installation of 1418 scanner.
- July 6—First 150 stores convert to OCR system.
- July 7—First saleschecks arrive at home office.

How well did it work? Beyond our wildest dreams! All our worries evaporated on that first day. The machine read 98 percent of the documents that first day and hasn't varied much from that level in one and a half years of operation. We clerically review, correct, and key-punch the 2 percent of the documents the machine can't read.

When looking back at the installation of a successful system, it is easy to gloss over the

difficulties and remember the more pleasant elements. This will not be the case at Thom McAn as far as OCR is concerned. We fought too hard to win in the face of a great number of frustrations. A company considering OCR applications may benefit by observing these battle scars:

1. Most OCR hardware is primitive compared with the sophisticated card or tape equipment with which we are familiar. Back-checking circuits are usually absent, and the machines must be programmed to perform some of this validity checking.
2. Optical reading stations are subject to inconsistencies. Don't take for granted that the machine will always read a given document. Of 1,000 documents read perfectly on one pass through the machine, ten may be rejected on the second pass. For this reason, we find that when rejected documents are rescanned 30 to 40 percent of them will be read. On the third try only 2 to 3 percent of the previously rejected forms will be read. Normally, we don't try them more than three times.
3. Much of the machine's ability to read "marginal" data rests on the skill of the service technician. A good one can tune the machine to read "impossible" data. A poor one may let the machine reject half of your documents.
4. Character substitutions are a fact of life. Poorly printed documents have a tendency to provide bad data—"3's" become "8's" and "5's" become "6's." Dirty optic heads and weak signal strengths in the circuitry produce the same results.
5. Personnel with OCR background are very scarce and the assistance available from hardware suppliers is usually superficial or of the "textbook" variety. For the next few years, OCR clients will have to learn mostly from their own trials and errors.

This evaluation of one company's experience with OCR may sound like a warning to stay out, but its purpose is quite the opposite. We only wish to point out the practical con-

siderations involved and the work that must be done to make a sound business decision.

Let's look at the advantages to Thom McAn:

1. Without OCR, we could not have done the job. The problems were so complex and the data so voluminous that no other system was practical.
2. One OCR system leads to another. It is so practical to let a machine read our source documents that we have branched out to capture new applications.
3. Finally, the potential of OCR is appealing. In spite of our labors, we haven't scratched the surface of the potential of even today's rather primitive equipment.

Earlier, I mentioned Thom McAn's wish for a machine that would read the handwriting on saleschecks. Such a machine could be programmed to read vouchers, cash reports, invoices, stock receipt tickets, and so on. In effect, we could bring all source documents into the machine and bypass the keypunch operation.

We could then obtain our data much faster and much cheaper. We could install many applications now impossible because of the expense or delay in translating source paper into machine format via punched card, punched tape, or some other means. Truly, such a machine could revolutionize current approaches to EDP and open up an entirely new phase of business technology.

At the New York World's Fair, one computer manufacturer displayed a machine that could read handwriting. Over the two-year period the machine read the handwriting of millions of people. The experience gained from that display should materially assist in the development of a commercial machine to read all handwritten business documents. It is no secret that Thom McAn is anticipating the marketing of such a machine in the near future. We're getting ready for a new and simpler approach to data input that will open new doors for all of us.

KEYS TO A MANAGEMENT INFORMATION SYSTEM IN YOUR COMPANY •

ADRIAN M. McDONOUGH

THE FIELD OF MANAGEMENT INFORMATION systems is so new, and is changing so rapidly, that it is impossible for anyone to really qualify as an expert. It is the very rate of change that causes many of our present difficulties.

The period in which we live always appears to us to be the one in which the greatest changes take place. The present is no exception. Today we face a world where new philosophies and new technologies are being proposed, tested, and absorbed at a rapid rate. The growth of knowl-

edge has reached a point where it has become a burden and, therefore, a challenge. This challenge is apparent when we consider the problems of organizing information to serve the appetites of all who would enlarge their personal knowledge. More specifically, in business and govern-

ADRIAN M. McDONOUGH is Professor of Industry, The Wharton School of Finance and Industry, Department of Industry, University of Pennsylvania, Philadelphia, Pennsylvania.

ment organizations we see large amounts of manpower concentrating on the search for facts and upon the interpretation of these facts.

The opportunity thus arises for studying the productivity of knowledge and particularly the productivity of management information systems. Productivity has in the past been associated with physical production. The "Taylor Movement" in the United States and the "Stakhanov Movement" in Russia resulted in greater understanding of the problems of physical production. Factory jobs were carefully analyzed and improvements were made at every level of the conversion of raw material to finished product.

Now there is a need for extending the concept of productivity to include all who work with facts and figures—those who collect, process, and interpret information. In the past such work has been treated as "nonproductive" labor. Today progress is increasingly dependent upon the efficiency with which we convert facts and figures into useful products as knowledge for management decisions.

The information in this paper is derived primarily from the work I have done in the field of information economics.* The work in information economics includes an exploratory attempt to define the problems of measuring productivity for "facts and figures" jobs. Facts and figures influence every administrative job from the lowest clerical positions to the top executive positions. Facts and figures influence the goals, the processes, and the results of all organizations. My approach, therefore, proposes that information be treated as a product and that both the values and the costs of information as a product be studied in the tradition of the scientific method. The ideas of information economics and management systems are presented with a hope that others will find them useful as they develop their own views of the productivity of information.

The title of my paper is "Keys to a Management Information System in Your Company."

* McDonough, Adrian, *Information Economics and Management Systems*, McGraw-Hill Book Co., New York, 1963; and Adrian McDonough and Leonard Garrett, *Management Systems, Working Concepts and Practices*, Richard D. Irwin, Homewood, Ill., 1965.

Keys, of course, are useless unless we can locate the right doors to unlock. Also, keys become obsolete when locks are changed. We must give due consideration to which doors we want to open and, especially, to why we might want to open them—and, remembering Pandora's Box, to why we might want to keep some doors closed.

The game of predicting what is going to happen in this field has been going on for some time now, and the stakes are getting higher all the time. This is apparent in the symbol of the third generation manager. We are no longer viewing data processing with a scope limited to machines and programming. Now the dimensions of the approach branch out to include all levels and specialties in an organization's list of positions. This means, of course, that not all of the locked doors are located in the machine room. We are now seeing that there are very few boundaries to where data processing might have an impact in an organization.

It is for this reason in particular that I have selected a few specific areas and will direct my remarks to them. These are areas that I believe should be of interest to the systems analyst, as well as to any manager who recognizes the importance of management information systems. I will comment on five locked, or at least sticky, doors that should be opened when seeking success in management information systems.

If we are to get behind the locked doors, I propose that the following five are among the most important keys:

1. Surveillance.
2. Criteria.
3. Classification.
4. Documentation.
5. Boundaries.

It is my impression that each of these areas contains fundamental restraints to the development and use of effective management information systems. Our systems can be no better than the state of the art in handling these problems.

THE FIRST KEY: SURVEILLANCE

Surveillance refers to all those activities by which a better perspective on an organization

and its environment is obtained. It includes coverage of both external and internal situations. It includes immediate and longer-range circumstances. In effect, it can cover every aspect of an organization; but, practically, an organized surveillance effort must be very selective.

I believe it is useful to think of surveillance as limited to the search for major changes in the environment of a firm. Surveillance of the environment of a firm is made difficult by the very fact that its purpose is to bring out and highlight those factors which require management to make changes. The management that is demonstrating its ability in the face of change does so by devoting resources to a very selective surveillance of its environment. Such a management not only looks inward at its base of operations but also goes out into its external environment in order to get firsthand knowledge.

Surveillance can be very informal, but more and more organizations are providing formal arrangements for certain aspects of surveillance. The payoff here for management information systems is that good surveillance can provide the best guidance for what should be included in the formal information systems. This is especially so in situations where change is typical. Progress can be made only if good evidence of where we are and good statements of where we want to go are available.

Surveillance can be viewed as a level of analysis one stage ahead of the actual design of the information systems. A good surveillance program, in this sense, is insurance that good specifications can be set for keeping systems design up to date. We need a better framework in which to design and evaluate our management information systems. A good surveillance program is one of the keys to getting better design and evaluation.

Consider the reality of the world in which we live. What is stable? What is not subject to change? Certainly not our information systems! Attention to surveillance will prevent the development of rigor mortis in our systems. Today's systems design must include flexibility to accommodate future changes. A priority given to surveillance arrangements, at a minimum,

can lead to the writing of better guidelines for systems success.

Let me go back over this point, because it is a difficult conceptual problem. Systems should not be designed in a vacuum. For any situation of significance a manager can ask, "What is it?" and, "What should we do about it?" At any point in time and experience, a first glimmer of a situation may appear. The difficulty is, of course, that the situation is rarely clear. In many business situations we are not sure of the factors, their significance, or their interrelationships. It is in the context of such vague situations that management problems are first identified and stated. This is the threshold level where the preliminary question is asked and the problem is stated for the first time. In the final analysis, no system can be evaluated except as it serves some purpose. The purpose can be spelled out only as we are able to provide effective surveillance of situations. We thereby obtain up-to-date descriptions of our information needs.

I am suggesting that more formal attention be paid to how our organizations carry out their surveillance activities. This will open the door to more concrete statements of the criteria with which information systems can be evaluated.

THE SECOND KEY: CRITERIA

Criteria, or measures of performance, have up to now been a rather academic exercise; this can no longer be the case. A major problem in government and industry is that we are spending fantastic amounts of money on systems and we do not know how to evaluate what we are getting for our money. We know what those systems cost, but we do not know what they are worth. Here is a real key to success in management information systems: concentrate on getting the real measures of the performance we should expect from our systems. This is the only way that I can see to do a better job in evaluating: (1) what the \$5-billion computer industry is achieving and (2) what over half of the people who work for a living in this country are achieving. The information industry is at least this big, and it is growing every day. What are the results of all this investment, all this time-consuming attention to information? Again, the answer can

be found only as we develop the analysis of criteria, the language in which we express values.

If we want to be able to evaluate the outputs of our systems we must be willing to spend more time and effort being specific about what we want from these systems. Getting to a better level of specifics requires that the managers themselves concentrate more on the formal expression of criteria involved in their jobs.

My assumption is that information systems serve managers in their job responsibilities. The reverse assumption, which is being made too often, is that the managers exist to serve the information system. It is because of this second assumption that we see so many conferences entitled: "The Impact of the Computer on Managers." The need today, however, is to look at the question of the "Impact of Managers on Computers." We are at a point where it is primarily the managers—not the hardware—that determine success or failure.

No matter how sophisticated the management information system is, it has to serve some level of management. The identification of the criteria appropriate to management at that level gives the best means to place values on systems outputs. Identification of criteria associated with various organization levels can provide a relatively crisp structure of an organization's decision needs. An approach that concentrates on criteria can get very close to spelling out the values that should be provided by a management system.

Much searching is now going on trying to find some way to put dollar values on information. I think that this is the wrong approach. We should be thinking in terms of the *real* measures of information values expressed in the criteria and units that fit the situation. Let me just note at this point that the Ten Commandments and man-made codified law provide important criteria for performance evaluation without using dollar units. In forcing our measures into dollar units, we may be distorting them to the point where they are useless. In budgeting, for example, the jump from the identification of problems to the assigning of dollars may

take place too fast. We tend to focus on the dollar figures in the final budget rather than on the analysis at the level of spelling out problems and their related criteria. I suggest that the budget procedure is one good place to start finding and using better criteria for information systems.

When criteria are not clearly spelled out, it is necessary to make forced choices—that is, choices based upon hunch and intuition. The study of criteria is one of seeking gradual improvements that will reduce the dependence on hunch and intuition. When good criteria are available, management can have more confidence in the answers to its questions.

The environment of an organization as it generates problems is the prime reason for any work in management systems. Problems reflect from situations where opportunities may be obtained or where hazards can be prevented. From a given situation at a moment in time, an organization seeks to take actions that will increase its opportunities and at the same time to take actions that will reduce its hazards. As the organization moves through its environment, individual participants identify their place in the scheme of things. They consider their organization position level and the time dimension of decisions for which they are held responsible. It is at such a time that the individual uses his management ability to identify the problems on which he will work and, at least intuitively, starts to assign priorities to his problems. In so far as his opportunities and hazards are synchronized with those of the overall organization, he weights his problems by their importance to the organization.

When the individual recognizes a lack of consistency between his personal interests and those of the organization, he is faced with the forces of compromise. The scales of opportunity and hazards that he sets for himself will be balanced by the repercussions he can expect if he gets out of line with the best interests of the organization. In any case, if the individual is to make logical decisions and is to take logical action, he must be as explicit as possible regarding both his opportunities and his hazards.

Again, he must select and express himself in statements of the priorities and criteria peculiar to his situation.

Criteria statements are logical extensions of initial problem definitions. They provide at least preliminary bench marks for testing the success of a project. Criteria are the English words with which we express the bases upon which we make choices. Any system that purports to aid decision making should be designed with conscious attention to criteria. Criteria become more meaningful when we are able to attach weights to the English words and thereby to make relative comparisons. This type of thinking is important in designing a system. It is especially important when attempting to set priorities among systems. Criteria statements can be quite useful when a management is attempting to compare and contrast projects and to set meaningful priorities.

Success in any job, at any level, must be measured against some set of criteria—some set of statements that separate the important from the unimportant. A manager in any job at any level has to:

1. Try to find out the criteria used by his superiors and, if appropriate, to help set such criteria.
2. Identify the criteria involved in his own job.
3. Provide criteria for subordinates.

Only as improvements are made at and among the levels of criteria is it possible to write meaningful specifications for the values that should come out of information systems. Criteria, I repeat, are the words in which values are expressed.

When I use the word "value," I am including two shades of meaning. The first is the type, or class, of what is being evaluated. This involves selecting the appropriate criterion. The second is the scaling, or attaching of a degree of importance. This involves putting weights on the appropriate criterion. To identify any value, therefore, a criterion must be selected and then a weight must be attached.

Criteria are necessary to spell out the responsibilities of a manager. They are, therefore,

necessary in spelling out the information systems that must support the manager as he tries to carry out his responsibilities. It is for this reason that I define information as "evaluated data." This definition allows us to tie information values directly to the selection of the criteria for success of any organization.

If we want to be able to do a better job, we must be willing to spend more time and effort being specific about what we want from our systems. This, in turn, may mean that we will have to cut back somewhat on the so-called total systems some of us are trying to build. There may not be enough resources to do a big and a good job at the same time. Getting to a better level of specifics requires that managers concentrate more on the formal expression of the criteria involved in their jobs.

Only as we make progress in expressing criteria in the job context can we expect to be able to attach values to our information systems. In a changing world, problems will change; and we must expect job content and systems content to change. Attention to the level of criteria can facilitate the implementation of such changes. No matter how sophisticated the management information system is, the manager must attach his values if he is, in fact, to have a job. Identifying criteria is a major part of his job.

THE THIRD KEY: CLASSIFICATION

Classification is another key area that is holding up progress in information systems. All information systems depend on classification, yet we really have very little knowledge about how to build good classifications. Work in classifying anything is tedious, and most people shy away from such work.

The importance of classification in information systems is, however, gradually being recognized. Classification is the very beginning of the organization of facts and information. Without classification there can be no information systems. Unless something is first classified it is impossible to measure it. With bad classification even the most powerful management

science techniques can be made ineffective. It is time to look at the problems of classification more carefully.

The decision to establish a business class, or to use an existing class, is the threshold at which we determine that a certain factor cannot be ignored. The identification of a factor as significant is the justification for including that particular factor. The recognition that classes should be selected carefully is a major step in minimizing the detail in an organization's systems.

There has been a tendency to build data processing systems upon existing classifications. Now we find that we have large investments in programming using these classifications. Such classifications are usually oriented toward use in quite separate functions of the business. Now we want to get integrated usage from our systems. If the classifications are not integrated, how can we expect to get integrated results from the systems?

We do not want *all* the facts—we want very selected facts. A selected fact is information. Selection should start with the classifications from which we build our systems.

Classifications are the building blocks of representations. These blocks can be big or small, gross or detailed; it is the critical job of the developer to match needs with an appropriate coverage of classifications.

A classification is a grouping of items of similar characteristics into classes or sets. This is not, however, a sufficient definition, for it ignores the need for identifying what we mean by similar characteristics. Further, it ignores the needs to treat differences as well as similarities. Let us look at this point more closely.

An overall classification development requires consideration of both differences and similarities. Similarities are sought so that they can be brought together in one place and worked on with a relatively uniform approach. Differences are sought in order to recognize when different treatment must be applied to the classes. A class, therefore, represents a grouping within which the subclasses fit together in relative harmony. These subclasses have meaning in the sense that they form the class as a whole. Contrasts of classes, however, emphasize the

need to identify differences and the significance of these differences.

This running back and forth between similarities and differences plays an important part in the development of a useful classification system. The fundamental idea is that classifications are built to facilitate decisions. Decisions involve both the making of comparisons for similarities and of contrasts for differences. In a good classification system, certain significant comparisons and contrasts are already built in.

Consider the mass production approach now being applied to the development of centralized data banks. If these banks are built before the classifications are carefully studied, they may simply turn into massive collections of unusable equipment. Data collection can become even more expensive and the results can become utterly useless. Classifications are very much involved in the quality control aspects of producing information products.

THE FOURTH KEY: DOCUMENTATION

Documentation is a real key today for those who are trying to keep track of all the details involved in the development of information systems. By documentation, I mean a recorded set of evidence showing the characteristics of some part, or all, of a management system. As our systems get larger and more complex, we are being overwhelmed by the expanding amount of detail. If we cannot keep track of what is in our existing systems, how can we ever make comparisons between existing and proposed systems?

Documentation of a system, or parts of a system, can be done in a careless or in a careful manner. In some cases, scratch pads and all other working papers are thrown in a file drawer (or perhaps a wastepaper basket). At the other extreme, every detailed decision made is carefully reviewed, indexed, written up in some standardized manner, and filed for easy retrieval. Both extremes are rare; actual practice is usually somewhere in between.

"Documentation" as a term is usually reserved for describing work at the levels of systems design and computer programming. It is here that we see explicit flow charts, pro-

gramming instructions, and computer-run manuals. I include other areas when I use the term documentation. One of the big areas where documentation needs to be improved is in those stages before systems design. In particular, I am referring to the needs for providing much better analysis and documentation of the specifications of information requirements. Only as these requirements are carefully chosen and documented is it possible to formfit the design of the system to individual manager's needs to know. Typically, information requirements will be expressed in the vocabulary of the manager's field of specialization, and this is just the way it should be.

Systems design is not the first step in the development of a management system. Unless the steps of problem definition and determination of information requirements are carefully documented, the stage of systems design may start with no clear-cut objectives—and this happens too often. What happens is that the systems designer, by himself, creates *his* problem definition and *his* view of the information requirements.

I believe that more formal pressure is being placed, and rightly so, on managers to provide the specifications for what they want out of information systems. This, of course, is where many of our programs for management information systems run into difficulty. It is not easy for a manager to spell out the information requirements of his job. Yet, if he does not, who can? If he does not, how can we expect better information? The frustrations existing here represent a key restraint to improvements in our systems. We are starting to see increased attention being paid to getting managers to become converts to information systems. This is anything but a simple problem. Flag waving and statements that the manager is responsible for setting his information requirements are not sufficient to get results. Managers must be given help in defining their information needs. An organized effort in a company documentation program can be a good start in helping managers to express their needs.

A documentation program in a company can serve as a rallying point for gradually improving the effectiveness of management infor-

mation systems. Documentation touches every level and every specialty in an organization. The variety of "languages" used in operating a business can cause confusion and consequent inefficiencies in operations. Documentation, at a minimum, highlights these problems. It gets them out in the open where something can be done about them.

Consider the possibility of having a manager's information "menu." This would be an organization's documentation of what can be available in existing information systems. The availability of a menu makes it possible to identify the set of choices for the manager and guides the systems designers as improvements are suggested. The menu of information available that can be served to managers can be viewed as the documentation of the important systems in the organization. With the information menu available, both the manager and the systems designer have a positive basis for discussing systems requirements.

There is a major need to have available much better means whereby the content in management systems can be identified and analyzed at various levels of detail. Progress in documentation will aid in the following situations:

1. Where add-on systems are being proposed.
2. Where systems are to be dropped.
3. Where the effectiveness of a given system has been challenged.
4. Where cross-relations within and between systems are to be studied.
5. Where audits of any nature are to be performed.
6. Where a new management technique has become available and consideration is being given to changing systems to exploit the improvement.
7. Where an approach is needed for penetrating parochial defenses of decentralized systems by reducing some of the barriers of complexity behind which parochial interests can hide.

Present methods for handling these problems are quite inadequate. At best they depend upon a voting process used by experienced people in the organization. More formal rules and techniques are needed to reinforce the judg-

ments of these experienced people. There are just too many detailed pieces involved in systems content to make much progress without some sort of an organized approach to improving documentation.

THE FIFTH KEY: BOUNDARIES

Boundaries represent the last key area that I will discuss. Here, I am afraid, we are being misled by all this talk about "total systems." The present quest for total systems should be recognized as a hazardous quest for the ideal. If the use of the term "total systems" leads to the impression that it is simple to integrate systems—or if it is only a merchandising slogan—then the term should be discarded. It is better to think of a system as being made more complete or more comprehensive. The question, "Should certain systems be integrated?" is just as important—if not more important—than the question, "How can these systems be integrated?" When nature puts certain odd systems together the result is often a freak. Managers and systems designers must guard against integrated but freakish systems.

As we try to increase a system's scope, or take on larger problems, there are compounding complications that set up restraints. We should recognize these complications and build our systems accordingly. Total systems are not good in and of themselves. In the production environment we had something like a total system years ago when one very large motor would drive many machines through a series of belts. Then it was found advantageous to set up separate systems with individual motor drives on machines. It was only when we were able to conceptualize the overall relationships of individual machines that we were able to move to integrated production systems, and even now this covers only a small percentage of our physical productive capacity.

A significant area of systems design is the setting of boundaries in which systems can operate with some measure of self-policing. The setting of boundaries is a key part of any problem definition. In practice, problem definitions are usually developed to the limits of compre-

hension of those involved in their design and utilization. We cannot design systems boundaries that go beyond our ability to define our problems. At some point things go out of focus and out of control.

We must not let the drive for progress put us in the position where we make promises that are impossible to keep. Too often I find false fronts on the stores that are peddling total systems. These merchandising outfits worry me, but it is their customers who buy the panaceas that worry me a lot more. A concentration on the problem of boundaries can quickly demonstrate the need for clear separation of systems.

Notice how the four areas that I discussed earlier all lead up to this problem of setting boundaries for separate information systems.

Surveillance, or lack thereof, sets limits to how well we see many of our most critical problems. Surveillance, therefore, greatly influences how many missing parts there may be that are not yet subject to integration through the systems approach.

Criteria must be available if we are to make decisions about the value of the services provided by an information system. Systems integration should take place only when we can meaningfully relate the criteria in the enlarged scope of the problem we have defined. In general, as we extend the boundaries of our analysis, we must be prepared to develop more explicit criteria.

Classification I described as the first level of organization of facts and information. Inadequacies and inconsistencies in our classifications are major restraints to our attempts to take on larger systems.

Documentation involves getting good descriptions of our problem definitions, of our information requirements, and of the logic of a system which can meet these requirements. The amount of effort now going into the seeking of better methods of documentation indicates that we are having a terrible time describing what already exists in our present systems. Note that many times we do not really tie separate systems together. In fact, we often cannot describe what exists and we start all over again trying to get the new and larger system.

In the area of management information systems the big challenge now is to tie systems content to job content. We are back with the emphasis on organization problems and are asking, "How can authority be balanced with participation?" We are starting to think about ways to relate the talents and the techniques available in an organization.

Talents are recorded in the minds of managers, and techniques developed by talented managers can be recorded in systems. Thus, one of the challenges of talented people is the need to provide good techniques. Such techniques are then put to use to make easier the handling of the organization's recurring problems. In simplest terms, a good technique records the use of good talents. The talent is built into a technique, applied as a system, and used over and over again.

A manager who believes that he can run his job without systems is mistaken. A systems specialist who assumes his system can run

the organization is mistaken. The emphasis should be on the extension and blending of management skills. A management should think of its systems, as well as its personnel, as being skilled. Skills in this sense can be built into a system.

This skill conversion is a vital link between the interests of the manager and the systems specialist. It is in this area of relating the manager's job content and systems content that I believe big payoffs can be achieved. The keys to this problem are improvements in the areas of surveillance, criteria, classification, documentation, and boundaries.

All things are somehow connected. There is, theoretically, in the ultimate, a wholeness. The basic fact is, however, there are so many things and, therefore, so many connections that man can work forever and yet discover only a small part of what there is to be known. I recommend the incremental approach to getting bigger and better systems.

IMPROVING CORPORATE PLANNING THROUGH ELECTRONIC DATA PROCESSING •

DR. ROBERT S. WEINBERG

THERE IS A GREAT INTEREST IN AMERICAN industry today in concepts of planning. About a year ago I undertook a serious study of planning practices in industry, and I met with the board chairmen, presidents, and chief executive officers and other senior executives of some of the largest companies in the United States. I was interested in what management expects from planning and, indeed, in what "planning" is. I reached some conclusions that are not startling. First, planning is as much an art as it is a science.

Second, planning is highly quantitative in nature. In fact, this might be one of the few top management interest areas that are indeed quantitative. Third, planning requires competent professionals. Fourth, planning must have management support and understanding; this is difficult to achieve.

DR. ROBERT S. WEINBERG is Director of Analytical Services, International Business Machines Corporation, Armonk, New York.

After searching the literature and looking at the work that has been done, I came to the conclusion that there are probably five kinds of people involved in planning. The first group includes the list-makers and the framework-builders. They tell you exactly what to consider but never how to consider it. I would say that, until quite recently, this group dominated the literature.

The second group is closely related: they are the inventory-takers. The inventory-takers can tell you exactly what everybody else is doing but not what you should do.

Next are the philosophers and theorists. These are the people who tell you what to do conceptually but avoid doing it.

In the fourth group are the wide-blue-yonder boys. They tell you exactly what is coming tomorrow but give you little insight as to what to expect today.

The fifth group is the group that I think is achieving the most. I call these the parametric thinkers and the professionally qualified guessers. Corporate planning is in many ways a great guessing game—one that is extremely important to the health and welfare of any company. The odds can be narrowed if this game is played with a computer, for then the players are in command of the information.

Four things have happened that have changed management practices. First is the increased availability of timely and accurate data. The second is the virtually universal availability of computers.

The third is the availability of a body of analytical knowledge—call it management science, call it operations research, call it quantitative common sense—it doesn't change the fact that there does exist a body of very powerful analytical tools. When I was a graduate student, we used to say you can ruin the mathematician by finding some practical use for his output. I think this has ceased to be the case. Primarily as a result of World War II, physical scientists and other analytical thinkers have developed a strange kind of union with policy makers and have provided all sorts of extremely powerful analytical tools.

The three factors I just noted provide a

logistical base for changes in management. The fourth factor, which creates the necessity for these changes, is the rapid change in the business environment. It is almost impossible to find a situation in the history of American business prior to the end of World War II where a single erroneous decision wreaked havoc in a large company. There are many situations where many poor decisions led to havoc; but there were marvelously few single decisions that had disastrous effect. Since World War II, however, there have been dozens of situations where a single erroneous decision was seriously detrimental to a company as reflected in the company's profit-and-loss statements. Does this mean that managers are getting dumber? Hardly. Managers today are far more professional and far more technically competent than managers have been in the past.

The reason is that business has become more complicated. In fact, I think the toughest realization for anyone who attempts to do analytical work involving management problems is the discovery that everything depends on everything else and that this dependence is influenced by many different things.

Through interviews with top executives I have come to the conclusion that most executives are concerned with seven broad management activities:

1. Setting the company's short- and long-term objectives.
2. Determining the company's overall policies.
3. Making or approving decisions that have significant impact on the company's future profits or operations with particular emphasis on promoting innovation.
4. Coordinating several major corporate functions.
5. Developing and maintaining an organization of qualified subordinates.
6. Delegating responsibilities and authority to the organization.
7. Controlling performance and results through at least one level of supervision.

I think these tasks, taken collectively, are the actions that distinguish top managers from other executives. Almost every top executive I spoke

to felt that working toward the achievements of the company's overall objectives was his own first objective. And for most of them planning and setting the company's policies and objectives ran a close second.

Probably not more than 2 percent or 3 percent of the large companies in the United States have established a meaningful set of corporate objectives, yet these objectives represent the very framework within which the strategies of the company will be established.

There are three approaches to planning. *Strategic planning* is concerned with the determination of objectives and with the selection of the most attractive combination of available alternatives for achieving these objectives. This area is almost wholly within the province of top management. *Tactical planning* is concerned with determining the most efficient use of the resources that have been allocated for achieving an already specified objective. The third area is *operating planning*, or *budget planning*. It is concerned with the development of a control mechanism to assure the effective implementation of the action specified in the strategic and tactical plans and with providing the basic measurement of actual performance relative to planning. All three approaches to planning are important to management and are indeed of great interest to management; however, my discussion will be concerned only with strategic planning.

DEVELOPING A STRATEGIC PLANNING SYSTEM

Relatively few companies do strategic planning. Why? First of all, the concept of strategic planning in business is a comparatively new one. The need to develop the strategic planning system is also new. In addition, the development of the meaningful strategic planning system involves a level of management participation and an availability of information that were not previously possible. Finally, it is a great temptation in business to be preoccupied with immediate problems at the expense of meaningful long-range planning.

I mentioned before that relatively few companies have established objectives in a meaning-

ful way. In general, the management of a company that is out-performing its industry has the corporate objective to maintain the position of leadership. The company that is performing poorly, relative to the industry, has as its objective to improve its performance. In general, a company with a profit margin of 6 percent and a growth rate of 8 percent wants to maintain a growth rate of 8 percent and a profit margin of 6 percent in the future—that is, as long as this growth rate and profit performance at least equal total industry performance. Very few companies, however, know how to look at the alternatives that are available for consideration. But the first step in establishing corporate objectives and corporate strategies *must* be the preparation of a list of these alternatives.

Why should management be involved in strategic planning? The planning process focuses management's attention and judgment on problem areas and, more significantly, on potential problem areas so that action can be taken to avoid problems before they arise. With computers and mathematical models, it is possible to look at many different alternatives. In talking to managements of companies that had embarked on major diversification efforts, I was amazed to learn that, more often than not, no more than two or three alternatives were considered.

The strategic planning system itself should provide a basis for looking at specific alternatives and specific opportunities to see for each opportunity what will happen to the business if it is accepted or is not accepted. The system will provide a basis for conducting feasibility analyses to determine what resources are required to launch a new undertaking and whether the company can generate them.

In designing a strategic planning system there are some technical requirements that should be considered. First, developing a set of objective criteria for measuring the company's performance is the starting point of management planning. Often the annual reports of leading companies include such statements as "We grew 8 percent this year, which is the greatest annual growth rate in the company's history." Frequently, however, the growth rate for the indus-

try in that year may be greater than 8 percent. So, on a relative basis, the company is doing poorly. Thus, establishing a basis for measuring *actual performance relating to potential performance* is extremely important.

Developing the capability to perform analyses in marginal or incremental terms rather than in terms of averages is the second requirement for a strategic planning system. Possibly the most frequent mistake made by businessmen is allocating resources on the basis of the average rate of marginals. That is, the company should plan in terms of what an additional \$100,000 in advertising or sales promotion will bring rather than determine the average rate of return on the first \$1 million spent and expect this rate of return on \$1,100,000. Very often a company will assume that if \$2 million in advertising produced \$30 million in sales, \$2.5 million in advertising will produce \$37.5 million in sales. Such reasoning can easily lead to the miscalculation of resources. This is an extremely important point, a point that a formal planning system will enforce.

A third requirement is to carry out the analyses and evaluations in the most meaningful levels of aggregation. If too much detail is considered, the system becomes too cumbersome. If, however, the analysis is too aggregate, important structural interrelationships will be lost in the aggregation process. The aggregation problem becomes important when several different individual products or market sectors are added together to develop a product or market group total. For example, it is possible for a company marketing in two or more submarkets to observe a completely different picture of their operations if an evaluation of their performance is made on a total market basis rather than on a submarket basis. The competitive performance of the American Tobacco Company from 1950 through 1959, offers a dramatic example of this phenomenon.

Company sales and brand sales data for the cigarette industry indicate that American Tobacco's competitive performance was favorable during the first half of the decade and highly unfavorable during the second half of the decade. In the absence of any further data we

might reach the conclusion that something went wrong with the company's marketing programs. If, however, instead of considering the cigarette market as a whole (a high level of analytical aggregation) we disaggregate the market into four submarkets representing the four types of cigarettes being marketed (regular, king-size, filter, and mentholated), a completely different picture emerges.

1. In 1951 the company's share of a major submarket (regular cigarettes) was down, but the increase in its share of the king-size market (and the increased importance of this market) created a situation where its share of the total market increased.
2. In 1952 the company's share of both markets in which it operated decreased, yet its share of the total market increased.
3. In 1953 the company suffered a major loss in the king-size market and a slight gain in the regular market, yielding a slight decline in the total market.
4. In 1954 the company made substantial gains in all three of its submarkets but registered only a slight gain in its share of the total market.
5. In 1955, 1956, and 1957 the company increased its share of market in each submarket in which it operated, but its share of the total market declined.
6. In 1958 and 1959 the company's performance in each of its submarkets was significantly better than its total market performance. (This was particularly true in 1959.)

It is interesting to note that in four of the nine years studied (1952, 1955, 1956, and 1957) American Tobacco's market performance in each of its submarkets was exactly the opposite of its performance in the total market. How is it possible for a company to increase its market share in every market in which it operates and still suffer from a declining share of the total market? The answer to this question lies in the fact that there were significant shifts in the structure of the total market.

If we examine the changing structure of the

relationships between the factors that determine the ultimate outcome of each strategic decision can we be sure that the actions specified in the company's strategic plan are consistent, feasible, and optimal.

USING THE STRATEGIC PLANNING SYSTEM

In the discussion above we were concerned with some of the specific technical or methodological needs that must be considered in developing a strategic planning system. We might call these needs "design specifications" or "requirements." Consider now the needs of the users of the strategic planning system. How will top management use the strategic planning system? The strategic planning system will provide corporate management with a tool for testing and evaluating decisions involving the major strategic "trade-offs" that must be considered in setting the company's objectives and in developing corporate strategy. The system will assist management in determining the most profitable balance between conflicting objectives. With few exceptions the major problems concerning top management fall into the following five broad categories:

1. Short-term profits versus long-term growth.
2. Profit margin versus competitive position.
3. Direct sales effort versus market development effort.
4. Penetration of existing markets versus the development of new markets.
5. Related versus unrelated new opportunities as a source of long-term growth.

The long-term success of any large enterprise is crucially dependent on top management's ability to establish corporate policies and objectives and develop growth strategies that reflect the most favorable combinations of these trade-offs.

The most important and difficult strategic decisions that top management must make are those involving the trade-offs between protecting an existing profit rate (or attaining a desired profit rate) and maintaining the company's competitive position. This is particularly true for companies which enjoy a significantly higher-

lower-than-average profit rate as compared with their competitors or the industry as a whole. A company with a high profit rate is faced with the problem of protecting it in the face of competition. A company with a low profit rate is faced with the problem of improving it without seriously weakening its competitive position. To be fully meaningful, any analysis of the trade-off between profit margin and competitive position should be carried out on an individual product basis, a product group basis (to include competitive or substitute products), or a market sector basis.

Decisions involving the trade-offs between direct sales effort and market development effort are particularly important to companies which are engaged in basic materials or new product industries. How can a company maximize its sales and profits? Is it more profitable to enlarge the sales force and increase promotional effort or to engage in research programs designed to find new and additional uses for the company's products? This point will be discussed more fully below. In general, we are concerned with establishing the most profitable balance between those expenditures designed to convert a prospective buyer of the company's products into a customer, and those expenditures that are designed to increase the number of prospective buyers by finding new uses for the product.

The last two strategic trade-offs are closely related. A company may achieve a desired growth objective by continuing to penetrate its existing markets or by developing new markets. If a company decides to develop new markets, the question of the relationship between the new product and the company's existing products becomes important. Top management must decide on a strategy regarding unrelated new market opportunities. For example, at what point will the company not consider a new opportunity because it is too unrelated to the company's existing products?

THE TOTAL CORPORATE PLANNING SYSTEM

We shall discuss some important aspects of new product strategies when we consider the nature of a corporate alternative evaluation and strategic planning model. Before we discuss this

model, however, it is useful to consider the total corporate planning system.

A complete corporate planning system will consist of five basic functional elements: (1) the corporate alternative evaluation and strategic planning model; (2) a problem analysis, model selection, and activity level generator subsystem; (3) an activity level to transaction input converter subsystem; (4) a transaction subsystem; and (5) an output analysis and display subsystem. In actual practice these elements may be combined and the functions of one or more subsystems can be combined into a single subsystem. Consider each of the functional elements and their interrelations.

The corporate alternative evaluation and strategic planning model is the heart of the corporate planning system. This corporate model will consist of a set of interrelated submodels. The number or types of submodels required in any specific corporate model will depend on the nature of the company's business and its planning philosophy. In general, these submodels will describe one or more of five basic types of relationships. The relationships are as follows: (1) the structure of the company's operating environments (market potential, market maturity, nature and degree of competition, and the like); (2) input-output or resource expenditure productivity relationships (production functions, market and product development requirement functions, and the like); (3) competitive interactions (competitive exchange rate relationships and the like); (4) timing response relationships (the relationship between the time, shape, and intensity of an outcome and the level and rate of input resources expended); and (5) the implications of alternative timing decisions (the impact of the timing patterns of different actions—new product announcement dates, timing of advertising and marketing campaigns, etc.—on the company's ultimate revenues and profits).

The purpose of the corporate planning system is to solve planning problems of the types discussed above. When these problems arise, they will be formulated in the language of management and not in the language of the corporate planning model. Often these problems will be stated in a very loose and imprecise manner.

The problem analysis, model selection, and activity level generator subsystem must be designed to analyze the problem, formulate it in terms of the variables included in the planning model, and select that combination of submodels that may be combined to generate a solution. In general, the solution of a planning problem will involve finding the answers to three interrelated questions: (1) Should a given action be taken? (2) If the action is to be taken, when should it be taken? (3) What resources should be committed to the action? These questions must be answered relative to the objective the company expects or desires to achieve by taking the proposed action.

The ultimate measure of the attractiveness of any action the company is considering must be expressed in financial or accounting terms: How will the proposed action affect the company's profit rate or rate of return on investment? What impact will this action have on the company's profit and loss (income and expense) statement or balance sheet? The output of the problem analysis, model selection, and activity level generator subsystem may often be measured in terms of "physical" activity levels that are not comparable with the "standard" inputs required in the company's financial or accounting transaction recording system. If this is the case, an *activity level to transaction input converter subsystem* must be developed. This is a translation subsystem designed to convert "physical activity" inputs into "standard financial" inputs for the transaction subsystem discussed below.

To be useful as a practical working tool, the corporate planning system must provide management with analyses, evaluations, and recommendations regarding possible action alternatives expressed in terms that are both familiar and acceptable as part of the company's normal decision-making apparatus. Any projections of the results that might be expected as a result of the action being considered must be expressed or measured in terms of those income statement, balance sheet, and related analytical data that management normally considers in evaluating any action recommendation. Ideally, the system should provide a basis for rapidly preparing a series of "before and after" income statement,

balance sheet, and operating ratio projections that can be compared, thereby providing an objective, factual basis for decision. *The transaction subsystem*, therefore, must be designed to provide the capability for quickly projecting the impact of any contemplated action on the company's income statement, balance sheet, and operating ratios. The transaction subsystem will represent a mechanized miniature aggregate version of the company's accounting and financial measurement systems.

The output analysis and display subsystem becomes important when many different possible alternatives are being considered. In developing a corporate strategy it would not be unusual to consider several hundred or even several thousand different possibilities. (Indeed, in the analysis of many complicated problems involving national defense strategy and the selection of weapon systems, Department of Defense analysts have successfully employed computers to examine and evaluate tens of millions of possibilities.) In considering even a relatively few important strategic trade-offs it would not be difficult to generate enough raw computer output to swamp even the most enthusiastic management. The output analysis and display subsystem must be designed to perform an analysis and synthesis function by "digesting" the output of the transaction subsystem and displaying this output in a form that will provide management with the most useful and meaningful analytical basis for decision.

THE CORPORATE ALTERNATIVE EVALUATION AND STRATEGIC PLANNING MODEL

The corporate planning system was designed to provide management with an analytical basis for solving strategic planning problems. As discussed above, the heart of the planning system is a series of submodels which are combined to develop the *corporate alternative evaluation and strategic planning model*. I would like to conclude this paper with a brief discussion of the elements of this model, since the preparation of its required building blocks represents the major contribution market research can make to the top management planning process.

The strategic planning model can take many

forms. A full discussion of the many different submodels that might be combined to develop a specific corporate model is beyond the scope of this paper; therefore, I will discuss the strategic planning model in its most general form. The basic relationships described below represent a system that can be adapted to almost any strategic planning problem. Consider first the kinds of data required to build the planning model. The construction of a strategic planning model will require the development of seven sets of basic building blocks. These building blocks are as follows:

1. Total market potential or economic environment planning factors.
2. Market development (product coverage and scope) planning factors and resource expenditure productivity relationships.
3. Market realization (or penetration) rate planning factors and resource expenditure productivity relationships.
4. Share of market and competitive impact planning factors and resource expenditure productivity relationships.
5. Price structure and pricing policy planning factors and market response (price elasticity) relationships.
6. Fixed or overhead cost planning factors and resource (or investment) requirement relationships.
7. Variable cost planning factors, production functions, productivity relationships, and resource requirement relationships.

These building blocks may be combined to answer the questions that are fundamental to the strategic planning process. In developing a corporate or divisional growth and profit strategy, seven basic questions must be answered:

1. What is the economic opportunity?
2. What is the salable market potential?
3. What are total industry sales?
4. What are company unit or constant dollar sales?
5. What are company actual dollar sales?
6. What are company costs and expenses?
7. What are company profits?

It will be noted that the first five questions, involving the factors which will determine the company's revenue or sales volume, can be an-

swered by combining the first five building blocks. It will also be noted that each of these building blocks requires data that must be supplied by the company's market research or market planning activities. To answer the sixth question, cost and expense data from the company's financial departments are required. The last question can be answered by merely combining the answers to questions five and six.

Given the structure and organization of the economy and the level of economic activity, business opportunities exist independently of the company's ability to take advantage of (or awareness of) these opportunities. The first question that must be answered in developing a corporate strategy or establishing long-term objectives is, "What are the economic opportunities for the company?" To answer this question, an estimate of the total market potential for all products and services that might logically fit into the company's product scope must be developed. This estimate should include *all* products and services, even those that are not presently included in the company's existing or planned product line. It is important to recognize the distinction between market potential and total industry sales. A market potential estimate is a conditional "if-then" statement. It should be constructed by answering the question, "What *would* total industry sales be *if* every possible prospect for the product were to become a user, and *if* all users of the product were to become maximum or optimum users?" The total market potential estimate can be regarded as an estimate of "potential potential." It is important to consider an all-inclusive definition for total market potential to provide management with an estimate of the extent to which the company's salable market potential can be increased through new product development or by adding new products through merger or acquisition. The total market potential estimate will also provide a basis for estimating the extent to which the company's product scope might have to be expanded to attain a desired long-term growth objective.

The second question that must be answered is, "What is the company's salable market potential?" That is, given the company's *actual* products and services, what is its "real" market

potential? While total market potential considers all products and services the company *could* market (consistent with the constraints imposed by its product scope), salable market potential considers only those products actually *included* in the company's product lines. The market development rate is a measure of the extent to which the company has developed its market by including all acceptable products in its actual product line. If the company has included all possible products in its actual product line, its market development rate would be 1.0, or 100 percent, and salable market potential would equal total market potential. By definition, salable market potential is equal to the product of total market potential multiplied by the market development rate. The company can increase its market development rate by adding new products to its product line.

The third question is, "What will total industry sales be?" Once the company's salable market potential has been estimated, a total industry sales estimate can be derived by multiplying salable market potential by an appropriate market realization (or penetration) rate. The market realization rate may be considered to be an index of market maturity measuring the extent to which all prospects for the products have entered the market and all users of the products have attained a full usage rate. If the market is completely developed, the market realization rate will be 1.0, or 100 percent, and total industry sales will be equal to salable market potential. In the case of new products, there will be a low market realization rate indicating that only a small fraction of potential users have entered the market. Any action the company takes to convert nonusers into users or to increase the usage rate of existing users will increase the market realization rate.

The fourth question is, "What will the company's unit or constant dollar sales be?" Company sales will represent a fraction of total industry sales. The competitive impact factor will measure the company's share of the market. Company sales will represent the product of total industry sales multiplied by the competitive impact factor. Any action the company takes to increase its share of the market will improve its competitive impact factor. Any actions com-

petition takes to increase its share of the market will weaken the company's competitive impact factor.

One of the most important instruments a company can employ in developing its corporate strategies is price competition. The company's prices relative to competitor prices for competing products or the prices of substitute products will determine the company's market share (competitive impact factor) and the rate of product acceptance (market realization rate). The company's pricing strategy will also determine its actual dollar volume, given its unit (or constant dollar) sales. The fifth question is, "What will the company's actual dollar sales be?" I have included this relationship and expressed the first four relationships in physical or constant dollar terms to provide an explicit basis for the consideration of the implications of pricing strategies.

The final questions to be answered are, "What will the company's total costs and expenses be?" and, "What will the company's profits be?" To answer the first question a set of cost and expense factors must be developed covering all phases of the company's operations. It is useful to consider both variable cost factors, which include those costs and expenses that are dependent on the company's sales volume, and fixed or overhead cost factors, which include those costs and expenses that are independent of sales volume. For the purposes of developing a strategic planning model, it is useful to consider costs and expenses classified according to *objective categories* rather than conventional income statement accounts—that is, all cost and expense planning factors and relationships should be summarized and classified according to the objective the company expects to achieve as a result of the resource commitment rather than in some more conventional accounting record summary. Since the strategic plan is concerned with determining the most profitable set of strategic trade-offs, all cost and expenditure data must be classified into objective categories that match the trade-offs being considered. For example, marketing expenses can be classified into those expenses that are required to maintain or attain a given share of market position; expenses (customer development) designed to improve the

company's market realization rate; or expenses intended to open new markets, thereby improving the company's market development rate. Similarly, product development expenses might be classified into those expenditures required to keep the company's existing product lines competitive; to add new products to the product line, thereby improving the company's market development rate; or to develop improved versions of existing products to attract nonusers, thereby improving the company's market realization rate. The success of the strategic planning system will critically depend on the ingenuity of the company's financial personnel in developing cost and expense objective category data. Once a projection of the total revenue and costs and expenses is developed, the final profit estimate may be derived by subtraction.

The ultimate success of any strategic planning program will depend on the ability of the company's market research and market planning personnel to develop the various market structure data necessary to relate the company to the industry and the industry to the economy, for market potential estimates provide the basic structural framework for strategic planning. Consider the fundamental choices available to management. Any corporate strategy must place first priority on protecting the company's existing market position or improving this position by capturing some of its competitors' share of market. The second priority must involve programs designed to improve the company's market realization rate by converting unsold market potential into sales. The third priority is to increase the company's salable market potential by developing the new products necessary to convert undeveloped market potential into salable market potential. The fourth priority involves changing the company's product or service scope to increase the company's total market potential. Management must determine the most profitable trade-offs in setting the company's competitive impact factor, market realization rate, and market development rate. These represent *all* of the actions the company can take in the marketplace. Through new product development, merger, or acquisition the company can change the markets in which it operates; but, once its markets are determined, only the choices out-

lined above exist. The other side of the profit coin involves skillful control of costs and expenses. The importance of such control should not be minimized. Each of the company's discretionary expenditures should be carefully reviewed to determine its exact contribution to the company's ultimate profits. Every discretionary cost or expense should be analyzed to determine its impact on the market development rate, the market realization rate, and the competitive impact factor; its contribution to increasing total market potential (by broadening the company's product scope); or its attractiveness as a cost and expense reduction investment.

Rapid changes in the business environment; new technologies creating opportunities; new competition at home and abroad; the high cost of undertaking new ventures; the large investments and long lead times necessary to enter new markets; increasing labor costs and severe price

competition; and the increasing complexity of business operations—all these factors place a high premium on thinking ahead, planning ahead, and staying ahead. The development of a meaningful strategic planning program is one of the greatest challenges facing corporate management and their professional staffs in the next decade. What I have tried to do is to give some insight into a problem that plagues top managers and present the problem in a fashion that would make the possible applications of the computer and use of the management information system fairly obvious. One of the interesting developments that I see for the future—five, ten, or even fifteen years from now—is that, as management information systems develop and as computers provide logical means for management to examine and consider alternatives, probably for the first time since the industrial revolution managers are going to manage.

INFORMATION SYSTEMS FOR BETTER MANAGEMENT OF FINANCIAL RESOURCES •

I. Areas for Financial Decisions in a Make-and-Sell Business

KENNETH E. TIGGES

THE OLD SAYING, "NOW YOU SEE IT, NOW YOU DON'T," typifies the character of the financial resources of a dynamic firm. While finances are one of the most critical resources of a firm, they are also one of the most elusive and changing in form. This is not by accident. A business must constantly convert these resources as rapidly as possible into goods or services with more profit potential characteristics than the financial resources themselves. It is this fluid condition which blurs the image of financial resources and

makes them difficult to discuss without encompassing the entire scope of corporate operations.

THE FINANCIAL CYCLE

Even though the financial resources of a company are in an almost continuous state of change, we can take a still-life view of the com-

KENNETH E. TIGGES is Corporate Comptroller, Owens-Illinois, Inc., Toledo, Ohio.

position of these resources at a moment in time—an action analogous to stopping a motion picture on one particular frame so that it can be studied more thoroughly. In the financial area this is accomplished through the means of a balance sheet. Under these static conditions we can identify the liquid resources of the company as cash and those short-term securities which can be readily converted to cash.

However, just as the stopped motion picture portrays only one point in time, so does the cash and securities figure on the balance sheet provide an incomplete view of our financial resources. The flows of financial resources into, through, and out of the firm can more readily be identified in the cash flow statements and statements of source and application of funds.

The flows of funds into the company normally come from two types of sources. The first source, hopefully a continuous one, is our customers who are induced to provide financial resources in payment for the goods and services received. The second can be a one-time source or, at best, periodic in the form of investors who provide financial resources in exchange for legal documents of ownership or indebtedness of the firm, for which they expect an appropriate return.

The uses of financial resources are many and varied. For illustrative purposes, the primary classifications can be listed in rather elementary form. Financial resources become "capitalized" into the more permanent facilities of the business; they are used to purchase materials for conversion into higher-value products; and they are used to compensate the workers and managers of the business. The combination of the facility, material, and manpower resources generates the goods and services, or the products, of the firm. A significant portion of the resources is used to satisfy the federal, state, and local requirements for taxation. And, finally, funds must be provided for interest and dividend payments to the investors, for the repayment of loans, and for further expansion.

The financial resource cycle becomes complete—in computer terminology, "the loop is closed"—when the products are sold to the cus-

tomers, a profit is generated, and the interest and dividend returns are made to the investors. The same investors do not necessarily reinvest in the firm on the next cycle.

THE DECISION POINTS FOR FINANCIAL RESOURCES

Each of the sources of supply, holdings of liquid assets, and uses of financial resources becomes a focal point for decisions in the management of financial resources. Therefore, they also become the key areas for emphasis in our information systems if these systems are to aid managers in making the best decisions for most effective management of the resources.

1. *Adequacy of financial resources.* The most crucial question which the financial officer faces is whether the financial resources will be adequate for the future needs of the company. The answer to this question lies in the critical balancing point of future requirements versus future availability and can only be pried loose with the tools of planning and forecasting. Again, the total spectrum of the business must be drawn together, since it is only through a good operating plan which reflects—as accurately as the future can be reflected—the planned activities of the company so that a financial interpretation of its cash needs can be made. Once the needs are established, the financial officer must then interpret the future of the financial marketplace so as to avail himself of the additional resources needed at the best possible price from the most advantageous source.

Financial resources—be they from new shareholders or from lending agencies—have a cost, just as do material and labor. To obtain the resources too soon can result in a penalty; to wait too long can mean entering the financial marketplace at a time when new debt or capital bears a high cost.

Let me state again that the answers to these questions cannot be generated simply within the organizational confines of the financial officer; rather, they must be fed in from the vast network of information systems and management decisions touching on every facet of the business.

The first concern in the management of financial resources is to make certain that these resources continue to flow into the company. Without this input the entire mechanism will grind rapidly to a halt.

2. *Customer sources of finances.* The uniformity and velocity of the flow of financial resources from the customers are highly dependent upon the nature of the business and the size of the firm. The selection of the markets and the cultivation of customer relationships normally are marketing responsibilities. However, the profitability of markets and even of particular customers has a definite impact upon the financial resources of the firm and their management.

The method of payment and the terms under which sales are arranged are of immediate concern to the management of financial resources. Credit policies which are so conservative as to avoid any losses due to bad credit may well result in turning away profitable business. Contrarily, if credit terms are too liberal and allow extended payment periods, the financial resources of your firm can be diverted to the customer, permitting him to operate on your capital. Information systems should provide the data to aid marketing personnel in selective selling as well as to predict the timing of cash flows from the sales.

3. *Investor sources of finances.* The flows of financial resources from investor sources are usually more durable and more predictable than those from the customer sources. However, in the company whose future needs for expansion cannot be met out of retained earnings, additional long-term capital resources will have to be solicited. This can be accomplished through borrowing or through the issuance of additional stock. Whichever course is taken, the decision is worthy of most careful deliberation, since it will have lasting effects.

If the decision is to borrow, the time limit for the loan must be determined, the type of loan must be selected, and the source of the loan must be chosen. If the stock alternative is selected, there explodes a further range of possibilities. In either case, accurate forecasts of future earnings and cash flows are essential so that management can be assured that funds will

be available for the repayment of loans or, in the case of a stock issue, that the values of present shareholders will not be diluted.

4. *Finances for facilities.* As mentioned earlier, the uses for financial resources range from investments in physical structures (which long may stand as evidence of the expenditure) to the purchase of services or the payment of taxes, where the benefits are of a much less tangible nature. On the more durable end of the spectrum, financial resources are converted into such facilities as land, buildings, and equipment, where there is usually a gradual deterioration.

Expenditures for facilities have a twofold effect on financial resources. The first and most obvious is the actual outflow of funds for new facilities and for the maintenance and improvement of existing facilities. Here, of course, the financial manager must be assured that control procedures are in effect which will allow him to forecast accurately the timing of the expenditures, as well as provide information on changes in plans which may result in overexpenditures. The second area, depreciation, is slightly more elusive. The book charge for depreciation is, of course, merely a method of spreading the cost of an asset over its functional life. Depreciation for tax purposes, however, may represent an opportunity to provide additional cash flow to the corporation through the use of the most advantageous procedure for income tax purposes, even though the manager may not wish to use the same method for financial reporting purposes. The advent of accelerated depreciation for income tax purposes in 1954 and the guideline depreciation procedures authorized in 1962 have both complicated the reporting of depreciation for income tax purposes and provided an opportunity for added cash flows to the corporation.

Since capital expenditure programs can be a serious drain on the financial resources of a company, particularly during a period of rapid expansion, one of the valuable services which a financial manager can provide is the establishment of good evaluation techniques regarding the profitability of proposed ventures. Some of the new mathematical techniques and the advent

of risk analysis which computer programs facilitate allow managers to more accurately predict revenues or savings from such expenditures and their long-range effect on the financial resources of the corporation.

Since the maintenance of existing facilities and equipment represents a heavy recurring cost, there is great opportunity in the area of repair-or-replace studies for cash savings to a company. The techniques in this area regrettably are still somewhat crude, but advances are being made.

5. *Finances for materials.* The usage and mix of materials used are strictly operating decisions. The calculated cost, both anticipated and actual, are matters for financial concern, as is the expected turnover. These are the areas where cost accounting and budgeting have flourished. An area for further financial consideration is the analysis of whether the materials or sub-assemblies can more economically be produced or bought.

6. *Finances for manpower.* The management of personnel resources is the concern of every supervisory position. The managers of financial resources are concerned primarily with the costs of wages, salaries, fringe benefits, and purchased services. An area where there must be more concern and more effort by financial managers is in the development of means for measuring the value of salaried personnel effort. The next step would be that of predetermining the value of effort. Such techniques would be helpful particularly in deciding whether or not to undertake such projects as systems design and research and engineering.

7. *Finances for products.* The decision point for products falls broadly into two responsibility areas. The area of determining the market potential for a particular item and for ascertaining the effort which will be necessary to penetrate that market is for the most part a responsibility of the marketing organization. However, when it comes to predicting and measuring the profitability of the item, many organizations may take part. The costs of doing business—whether directly a part of the product, indirectly related to the product, or just general overhead—must

be calculated and allocated to the product. This is usually an accounting function. The margin decision (what the product can be sold for) is a highly sensitive and critical decision involving the management of both the marketing and financial functions.

8. *Finances for taxes.* Taxation is a decision area of vital concern to the management of financial resources. The use of corporate funds for payment of taxes based on income, property holding, employment, and numerous other bases requires specialized management and equally specialized information systems. In fact, the emphasis on reporting for tax purposes has in the past often taken on such proportions as to dominate the information system structure. For example, many companies adopted the most advantageous tax procedure for financial reporting even though management and shareholder reporting purposes would have been better served by another procedure. The advent of the computer with its capacity for handling great volumes of data in dual systems is allowing the separation of these considerations.

9. *Return to investors.* The final area for our consideration in the management of financial resources—although certainly not last in terms of actual concern or importance—is that of return to the investors, whether they be owners or creditors. Here, the need is first to meet the legal commitments for interest on borrowings and the dividends on preferred stock. It is further necessary to determine the dividends which should be declared on common stock to keep it sufficiently attractive to investors. Balanced against the earnings to be paid out to investors must be a consideration of that which should be retained in the company for future growth. Finally, provision must be made for the repayment of principal to lenders as well as the retirement of preferred stock.

These nine decision points comprise the major areas of concern in the management of financial resources. They identify focal points for concentration of information systems if the systems are to be of greatest value in the management of financial resources.

II. Information Systems for Financial Resources

THOMAS H. BROWNING

DURING THE PAST SEVERAL YEARS THERE have been significant advances in information systems to support the decision-making process relating to financial resources. Many of these systems have been computer-based. The quantity and quality of these systems have been relatively high and have made a favorable impact on financial management in our major industrial institutions. In this respect, the progress of Owens-Illinois is fairly representative of the situation in industry today. Some companies have made greater penetration into certain areas and on total balance some are ahead of us, but we are not far behind. I will discuss here the criteria established in the preceding paper to show how Owens-Illinois has faced the opportunities and problems encountered in the financial decision-making process.

1. *Availability of financial resources.* The first decision point is concerned with the adequacy of financial resources to meet future needs. It is ironic that this is the last point to get an answer; to be able to answer this question with certainty would necessitate a completely integrated financial reporting and forecasting system covering all phases of the business. This we don't have, and neither do many other firms.

The nearest we can approach to this information requirement is with a corporate general accounting system which is computer-based. This is a financial system which provides information for compilation of the usual financial statements plus much of the information needed for management of financial resources. The information generated by this system has reduced the time lapse in the preparation of information, and it does provide a factual basis from which to launch our financial projections.

2. *Customer sources of finances.* Information concerning input to our financial resources through the customer channel has been greatly

improved through a computerized marketing and profitability system. This system provides basic sales information, both unit and dollar, for a major segment of our business in a much shortened time period. It combines cost information with sales information to identify sales margins by customer, with a breakdown by product lines. This information enables us to identify sales performance and profit contribution at any level of the sales organization. It enables better decisions on the allocation of costs. Most important, it provides valuable information on the profitability of various marketing areas as a basis for better direction of marketing effort and improved generation of financial resources.

3. *Investor sources of finances.* Decision point three is concerned with the selection of investors to encourage to be suppliers of financial resources. To date, we do not have any computer-based systems which directly generate the information necessary for these decisions. However, the variety of information systems outlined here provides much of the information which must be used by managers in determining the mode of financing new capital expansions.

4. *Information for uses of financial resources.* As indicated by Kenneth Tigges in the preceding paper, the use of financial resources for facilities can be a heavy drain on the capital of any company. The financial considerations are of two types. The first is concerned with actual expenditure for new facilities and for maintenance of existing ones. The second decision is concerned with the most effective means of calculating the depreciation of the investment.

A computer program to aid in the analysis of proposed expenditures for new facilities or

THOMAS H. BROWNING is Corporate Manager, Data Processing Administration, Owens-Illinois, Inc., Toledo, Ohio.

new products has been developed by the comptroller's staff at Owens-Illinois. This program calculates the usual discounted cash flow information and applies factors of probability to the calculations. The result is not a single discounted cash flow figure. It produces a range of possible rates of return and their probabilities of occurrence. Such a tool can aid managers in evaluating the risks involved in any proposed expenditure.

Information reporting the actual expenditure on new facilities under construction is available out of our property accounting system and enables better decisions on the expenditure of funds. This system further calculates depreciation on the capitalized items according to the methods designated for book and for tax purposes. This system provides information to financial management to aid them by projecting cash flows from tax depreciation.

5. *Computerized measurement and reporting of basic materials.* Some of the basic materials which go into our products are sand for the manufacture of glass and paperboard for the manufacture of shipping containers. Computerized measurement and reporting of glass batch materials are being introduced into our glass plants as a means of more precise material control and for more accurate management of the inventory of raw materials. Nearly all our company's paperboard inventory and usage are reported under a nationwide, computerized, roll stock control system. This information provides for better allocation of financial resources to this key material resource.

6. *Information systems and personnel resources.* Our company, like most companies, cut its computer teeth on hourly and salary payroll applications and then developed substantial computer programs to help control efficiency and costs. The effects of these employee systems on financial resources have been most significant in those manufacturing locations where the costs are more variable.

7. *Product marketing and inventory management.* This decision point is concerned with which products to market, whether to make or buy, and the efficient management of inventories. The marketing and profitability system described previously generates information helpful in de-

termining which products to market. Considerable progress also has been made in the management of finished goods inventory for more than 60,000 stock items. This control begins in the order processing system which consists of a transmission network linking 130 company locations. Minimal sales order information originating in the sales branches is transmitted to a computer center where it is exploded into full sales and factory orders. Inquiries are made to determine whether stock items are available. As goods are manufactured, stock record quantities are automatically increased. As goods are shipped, the invoices are automatically prepared and stock level records are reduced.

The impact of these systems on our financial resources is in the rapid response of the order preparation and invoicing system. It serves to speed up the flow of resources through the system in terms of the time it takes to enter an order, release the shipment, and bill for the goods. Less of our financial resources needs to be tied up in the order cycle and finished goods inventory.

8. *Automatic calculation of taxes.* The general accounting system described previously in this paper calculates automatically many state taxes and our Federal income tax. Taxes based on number of employees and employees' wages are calculated as part of the computerized payroll systems.

9. *Payment of interest and dividends to the investors.* Here there is a share-owner system which handles stock transfers, proxies, dividend payments, and other matters that support the share-owners' investments.

* * *

It is apparent that our company is beginning to close in on many of the systems which provide information necessary for the management of financial resources. And, as I pointed out earlier, this progress is probably typical of firms which are moving ahead with their computerized systems.

At the same time, it must be apparent that most of these systems are designed to be of help on the operating level for both financial and nonfinancial resources and do not respond auto-

matically to the planning and control requirements of our financial resources. However, it is from the operating systems that most information for management decisions must be drawn, whether it is done manually or automatically. Therefore, the operating systems must be well defined and established before such penetration can be made into the more nebulous field of management information.

Our company already has made progress in the development and use of more advanced management planning and control information. Portions of this material are being assembled with these computer systems. It is my prediction that much more of the planning process will be programmed to the computer in 1967. This will greatly reduce the clerical strain now necessary to compile this information, thereby enabling managers to consider the effects of more alternatives before settling on their objectives and action programs.

A great deal of forecasting work already is being done with the aid of the computer. A number of forecast routines are available for mechanical projections of sales series and inventory levels. Most of these techniques are off-line systems, run on a special-request basis. As these techniques become more refined and more familiar to managers, it is quite probable that they will become more of an integrated part of our routine information systems. It is my opinion that during 1968 we will have begun to incorporate enough sales and cost forecasting into our systems to have the capability to forecast effectively a high proportion of our financial resource situation as a routine part of the system.

Further advances will be made in subsequent years as external environmental information is made a regular part of our information systems. Much of this type of data is already commercially available at nominal cost. The net effect will be that planning for availability and use of

financial resources can be performed more effectively as a result of this broader information base. It should enable one to see farther in advance and also to detect sooner the changes which will significantly affect our plans.

As I see it today, the ultimate in advanced information systems will be in computerized models of our financial information systems which can be manipulated by the managers themselves. These models will enable simulation of actual conditions under varying circumstances and alternative decisions. Such a model should permit development of information systems which will automatically predict when conditions are going to exceed acceptable limits and notify where and when corrective action should be taken.

In my opinion, another criterion for advanced financial resource information systems is that the financial controls must be built into the system. When an appropriation exceeds limits, the flow of funds should automatically be cut off.

The major problem in the construction of more advanced information systems is the ability to communicate effectively and broadly to gain the greater involvement needed as progress is made from conversion and integration of well-defined routine systems—such as those described here—to less defined and more complex management of financial resources. Unlike the earlier endeavors, which in a large part could be delegated to technicians for conversion, the current projects require that higher-level managers take part in the design of each project and assume primary responsibility for its success.

In conclusion, it is to be noted that the systems for financial resources described here have been constructed in response to opportunities and problems rather than according to any grand plan. We have worked hard at planning, but we have found in the real and practical world that it is most difficult to construct and adhere strictly to a master plan.

INFORMATION SYSTEMS FOR BETTER MANAGEMENT OF MATERIALS RESOURCES •

WILLIAM J. EDMUNDS, JR.

and

ALAN R. EAGLE

THIS YEAR MARKS THE TWENTIETH ANNIVERSARY of Kaiser Aluminum & Chemical Corporation's business which started with the leasing of three facilities from the War Assets Administration. First-year sales amounted to some \$45.4 million. The leased plants were later purchased, and today we own and operate 47 facilities in the United States and own or participate in 28 facilities in 18 foreign countries. Sales have grown steadily and reached \$576 million in 1965. In aluminum we are fully integrated, from bauxite mines to finished aluminum products. We have diversified into refractories, chemicals, and real estate.

Our Jamaican subsidiary delivered more than 5,400,000 tons of bauxite to U.S. facilities in 1965. (Bauxite is the reddish ore from which white powdery alumina is extracted. Alumina is then reduced to aluminum in electrolytic smelters—reduction plants.) We are currently developing bauxite reserves in Australia, where we are also constructing a 600,000-ton alumina plant. We are building a 100,000-ton smelter at Tema, Ghana, to augment 650,000 tons of smelting capacity in the United States. Aluminum markets are being expanded worldwide. Our future planning involves consideration of additional ore sources, plants to produce alumina, smelter facilities which use large quantities of electrical energy, and locations for plants to produce semifabricated sheet, extrusions, rod, wire, and other products.

Our rate of growth has made it both necessary and profitable to expend considerable energy and funds in data processing and com-

puter analysis. Particularly in the area of materials resources, we now have successful programs able to provide prompt, accurate production and inventory data for all major production centers. We have a rather complete system of inventory control for plant stores items which aggregate \$10 million. This system automatically prints new purchase orders at a central location when any stores item reaches the reorder point. Production scheduling for all large facilities has been computerized. Eleven warehouses are currently installing IBM 6400's to improve control and analysis of warehouse activity.

We have chosen for discussion here two specific areas where Kaiser is currently developing more systematic information for decision making.

SCHEDULING AND CONTROLLING THE MOVEMENT AND USE OF PRIME METAL RESOURCES

The first of these areas is the problem of supplying cast products to our fabricating plants and to customers. A very complicated logistical plan is made necessary by the following conditions:

1. Five fabricating plants and four smelting plants are equipped to produce cast products for 12 widely separated fabri-

WILLIAM J. EDMUNDS, JR. is General Manager, Supply and Distribution. ALAN R. EAGLE is Manager, Management Information Services, Kaiser Aluminum & Chemical Corporation, Oakland, California.

cating operations and to provide similar cast products for sale to customers in the United States and abroad. Casting units at the four smelting plants may supply a customer directly, or may ship cast pure ingot to any of the five fabricating plants equipped to "recast," which in turn ship to the customer.

2. The product mix includes over 200 alloys and about 100 different shapes or sizes. Complicated purity controls are necessary to provide the proper grade of pure ingot for alloying purposes.
3. Production capabilities overlap, but no two casting centers provide identical availabilities for alloys, shapes, and purities. Both freight cost and value added at the production centers vary with the choice of supply plan.
4. Constant and often unanticipated changes in the product mix make it essential to provide maximum flexibility for scheduling to obtain optimum service at minimum cost.

Given these complex, interrelated conditions, we are constantly adjusting to minimize only those costs *which can be quickly recognized*. There are serious deficiencies in this method of programming our cast products, because shifts in product from one plant to another nearly always require a compensating change in products at other plants, making it difficult if not impossible to *quickly* recognize and evaluate the total or aggregate change in costs—and changes in cost easily recognized (as with direct freight) are often outweighed by opposite changes in costs not easily recognized (as with variable production costs or purity control costs).

Intense competition prevailing in the marketplace demands quick analysis and decision as to our cast-product availabilities. For example, our marketing people may develop an opportunity to market alloy ingot in the European Common Market. Additional quantities of alloy ingot could be produced at Newark, Ohio; Ravenswood, West Virginia; or Chalmette, Louisiana. Although Chalmette would have the lowest cost source from a freight standpoint, the plant's

casting units may be at capacity, or metal availability from the reduction cells may be sold out. If so, what is the best shift of demand from Chalmette to another facility to make room for the new requirement? Will such a shift be more or less costly than producing the European requirement at Ravenswood or Newark even though freight costs are higher? If casting capacity is available at Newark or Chalmette but pure metal is *not* available, can Northwest metal be supplied to Eastern facilities so the casting units may satisfy the new demand? What will be the effect on overall costs under the various alternatives available? Each plan must consider:

1. Volume limitations on pure metal from smelting plants.
2. The matching of purities produced with purities required.
3. Volume limitations with units to cast the metal into desired shapes.
4. The freight and production economics of multiple choices for each weekly schedule.

We have confirmed that very substantial improvements in costs may be achieved if we can quickly evaluate all the data available and if we can update information as conditions change. Accordingly, we have asked our management information services to provide a computer system which can analyze our cast products plan quickly—on short notice—and at regular intervals, and which can be continuously updated to reflect current cost information.

SYSTEMS DESCRIPTION (SCHEDULING AND CONTROLLING PRIME METAL RESOURCES)

Many of these problems are handled by a new computer-based system that we are implementing. Each quarter, this system will determine what cast products to make at each of our casting facilities to satisfy each of a large number of demand points. Each week the system will schedule the shipments of metal about the company to minimize total freight costs and conserve metal purity.

The model on which this system is based considers all the prime metal facilities, the

casting facilities, the customer demands, and the distribution network that ties them together, as one integrated system. (See the accompanying exhibit.)

The model incorporates our facilities for reducing prime metal—that is, for converting alumina to aluminum in a pot line—and the sources of scrap metal. (Some prime metal is purchased from sources outside the corporation.) Hot metal is fed directly into casting facilities, several of which are located immediately adjacent to the reduction plants, or is cast as pig or prime sow and shipped cold to other plants where it is remelted and cast to produce a variety of cast products.

The major groupings of cast products are formed by the model into 400 combinations of alloy, size, and geographic location to satisfy customer demands and the demands of our own fabricating plants.

A considerable amount of geography is involved in the physical system. Some of the casting facilities are adjacent to the reduction facilities, but other routings entail a shipment across the country. Some of the demand points are domestic, others are international; so freight costs are a significant part of the overall problem. For each route there is a freight cost per pound that depends on the route, a production facility usage rate per pound, and a marginal production cost per pound, all of which depend on the facilities utilized for reduction and casting.

The total cost of moving prime metal from any given reduction facility through any given casting facility to supply a given demand is proportional to the number of pounds moved. Thus we have a linear cost relationship for metal movements. Similarly, the marginal *production* cost for a particular reduction plant or a particular casting facility is a function of the number of pounds of product produced there; hence, these costs are also linear. Capacity and blending restraints associated with each casting facility can also be expressed as linear relationships so that the problem can be formulated in a linear programming format; and that is exactly what we have done.

We put into the model a quarterly forecast of

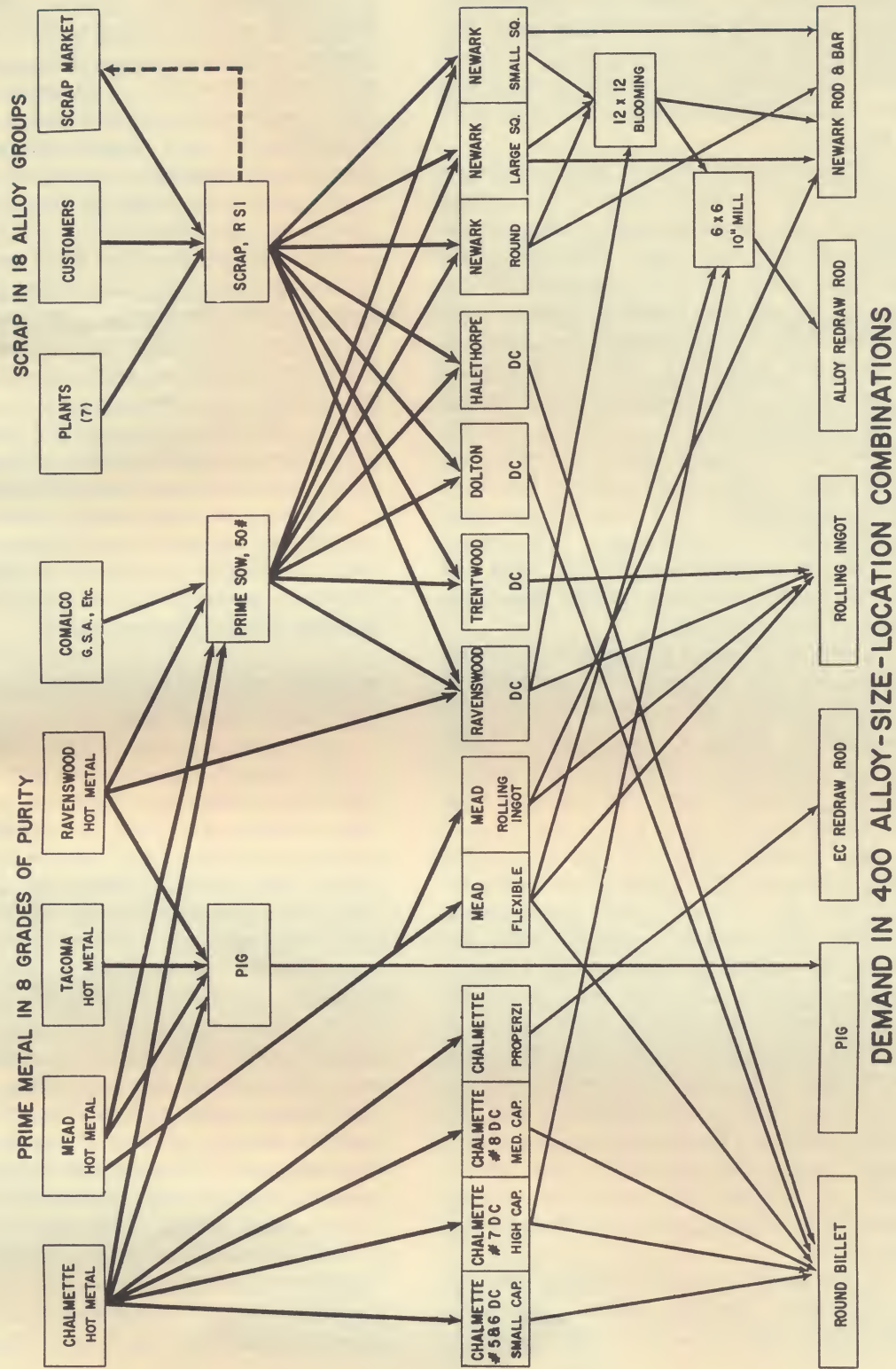
demands for each of the 400 alloy-size-location combinations. The model determines how much metal to move over each of the routes shown; in other words, how much of each type and size of alloy to produce at each casting facility for shipment to each customer location, to satisfy all demands at the lowest *total* of the marginal production and freight costs. The quarterly run thus determines:

1. The order assignment rules for the quarter; that is, the assignment of demands (broken down by alloy-size-location) to individual facilities.
2. The facility-hour-usage forecasts, for manpower scheduling.
3. The outside metal purchase requirements, for procurement planning.

Our original intention was to run the model only quarterly as a planning guide. However, we soon realized that the situation changes too fast for quarterly runs to be sufficient. Day-by-day contingencies at a production plant, a casting plant, or somewhere along the transportation system often force us to depart from planned operations and to use high-cost routes, to waste metal purity, to miss delivery schedules, or, in rare cases, to shut down a furnace. Much of the savings potential of the system—that is, the difference between the optimum distribution pattern of the quarterly run and the routings actually used—could not be achieved because of such short-run scheduling problems. Hence, it became obvious that we must supplement the quarterly run with more frequent runs for scheduling purposes.

We discovered that the most serious scheduling problems occurred in the intracompany movement of cold metal—the movement of prime sow to the casting facilities. This movement involves problems of blending grades of purity at the casting facilities. The blending problem is particularly important this year because of the requirement for working into the system large quantities of low-purity purchased metal. We want to conserve the high-purity content of the better grades of metal coming out of our reduction facilities, to blend it with the lower grade purchased pig so that we achieve—but don't exceed—the purity requirements at our

CORPORATE CAST PRODUCTS MODEL



casting facilities. By meeting these requirements exactly we will be able to blend in more purchased metal than we could if we did not take purity requirements into account in calculating short-term shipping schedules, as we have done in the model.

We set up a procedure by which all sources of prime metal supply throughout the company telegraph into the metals control office at corporate headquarters each Wednesday the amount of metal they have available in inventory, the amount they intend to produce in the coming week, and the amount they intend to produce two weeks out. This information is broken down into product grades reflecting metal purity and content of alloying elements. Just as we receive supply data from each prime metal plant, we also receive demand data from each casting facility. This, too, is telegraphed into Oakland every Wednesday. Included are the metal requirements for the next week and for the second week out, broken down into grades of purity and alloy.

A number of checks are made on the supply and demand data received from the plants to eliminate obvious errors or situations where requirements greatly exceed supplies. Afterward, the data are keypunched, converted to magnetic tape, and transmitted to a local service bureau.

At the service bureau the data are fed into a special program which generates a matrix for entry into the ALPAC linear programming algorithm. The ALPAC program solves the model and outputs the answers via a special report generator routine that prints out results in a form easily interpreted by operating people. The output contains an optimum shipping schedule for each of the coming two weekly periods, the first of which is considered firm and the second tentative. This same process, covering a month's supply and demand, is run once a month to determine the appropriate delivery points for the various grades available from outside sources.

A few words about the objective achieved by the weekly scheduling system: The model first assigns metal shipments to demand points

so as to minimize *total freight costs*; then, while holding the minimum freight costs, it allocates blending purities among receiving locations so as to meet the quality requirements with the least possible metal purity. This has the effect of hoarding the purity content of the metal, thus improving our capability to react to emergency requirements or to blend additional purchased metal in later time periods.

In summary, then, we have developed a system that serves as an intermediate-term planning guide in determining what products to make at which facility, and as a short-term scheduling system for minimizing freight costs on intracompany movements, for conserving purity in blending alloys, and for coordinating our integrated manufacturing operations in a system oriented toward common objectives.

Although we have not yet solved all the problems in this area—parts of the system are just now becoming operational—we are well on the way to complete implementation of a very workable and satisfactory system.

PLANNING THE EXPANSION OF RAW MATERIAL PRODUCTION FACILITIES

The second area to which we are now directing considerable attention is our long-range planning for basic ore, alumina, and smelting resources. It will come as no surprise that we are actively planning for the longer range, and anyone familiar with this activity will know that long-range plans are involved with many alternate courses of action. Plans must be flexible to include new alternates, even on a tentative basis. Managements seldom commit to a specific course of action until absolutely necessary. Our company is no exception. We are considering so many alternates that some of our managers question whether we actually *have* a long-range plan. Decisions are sometimes made as though no plan exists, because the plans are complex; they involve many alternates which are difficult to analyze without examining a very large number of possibilities.

Although we have considered the wisdom of earlier commitment to future action, we are

now thinking that the computer sciences may enable us to reserve flexibility, yet still significantly improve the quality of today's decisions as they relate to future costs. We believe that through computerized systems of information a necessary decision can be tested under all probable courses of action, on short notice and in sufficient depth to greatly improve the accuracy of assumptions which will have significant bearing on future costs. To cite an example: We are negotiating a contract of affreightment for the movement of bulk alumina from Queensland, Australia, to Tacoma, Washington. If we can be relatively certain this movement will remain a part of our logistical plan for ten years, say, we can agree to a guaranteed freight contract and save \$1 to \$2 per ton, as against an uncertain arrangement. Further, if we can be relatively certain of the movement, we can afford to finance more expensive but more efficient unloading facilities to obtain an additional decrease in per-ton costs.

Lacking *commitment* to future plans for ten years and lacking *the ability or time to assimilate* all the factors affecting the many alternates, we have tended to provide more flexibility than needed. The result is higher operating costs.

To resolve the Queensland-Tacoma alumina matter, we tested the costs of various hypothetical logistical plans assuming a third source of bauxite, three additional facilities for alumina production, and seven possible new smelting sites. All probable combinations retained Queensland as supply to Tacoma, and we are proceeding on this basis.

We are trying to develop these techniques in greater depth. They are indeed the same techniques necessary to determine the best future plans. We hope to maintain updated information on all sites under consideration for expansion and on all supply, distribution, and capital costs which bear on expansion decisions, and to correlate this information with market forecasts which themselves must be continuously updated. As this endeavor proceeds, our decisions will continue to involve judgment and risk. However, we expect the ability to assimilate and comprehend this maze of information will

enable much more precise evaluation of risk and probabilities. The resulting higher-quality decisions will greatly assist our efforts to obtain maximum efficiency and minimum costs.

SYSTEMS DESCRIPTION (EXPANSION PLANNING FOR RAW MATERIAL PRODUCTION FACILITIES)

The questions involved in freight movements are typical of the problems which arise in a number of areas that are related to each other and to the long-term expansion plans for the raw material end of our business. None of these questions can be handled correctly without involving several others regarding site locations, freight costs, sales forecasts, and related matters projecting well into the future.

To tie these elements together into an overall plan we developed a systems formulation of the problems of expansion planning for our alumina and aluminum reduction facilities and the related distribution networks. At the heart of this approach is a mathematical model that determines when to expand, how much to expand, and where to expand each of our present facilities and each of several potential new sites for aluminum and alumina productions. The expansion is determined to meet a given year-by-year forecast of metals requirements at the lowest present worth of all relevant future cash expenditures over a ten-year planning horizon.

As in the previous model, the reduction mills ship a part of their output to customers and a part to our own fabricating facilities. For both alumina and aluminum there are a number of existing facilities that can be expanded and a number of potential new sites that could be brought into production in any given year. The penalty for bringing a new site on stream is a high start-up cost for building facilities, such as roads, harbors, hospitals, and housing. These are one-shot expenses over and beyond the cost of expansion at any of the existing facilities. The advantage of a new site may be a reduction in unit operating costs or in freight, tax, or tariff expenses. There are numerous combinations of new and existing sites that we want to compare and evaluate.

Our objective is to select the least-cost sites. The principal costs are site preparation, capital, and operation costs. These costs are diverse in nature. Capital costs, for instance, are experienced almost entirely at times of expansion, whereas operating and freight costs are experienced continuously, year in and year out. This poses a problem of comparing sites when one site has higher capital but lower operating costs than another. The problem is resolved by using the present value of "cost" cash flows as the basis for comparison.

The concept of present value. Assume that we have two sites that we might expand. The capital cost for expanding site *B* is \$30 million per 100 million annual pounds of capacity, compared with \$25 million for site *A*. But the operating cost for site *B* is only \$3 million compared with \$3.5 million at site *A*. Without the use of the present value measurement of cost, we have no way of determining whether *A* or *B* is better. Accordingly, assuming a 12 percent cost of capital, we have applied the present value factor, for each year from one through 20, for capital costs and operating costs. We extend the cost figures by their present value factors and total the extensions. The total present value of the costs of operating site *A* is less than site *B*, so we conclude that site *A* is preferred.

In other words, the extra \$5 million required to enter site *B* in the first year is not offset by the \$.5 million per year saving in operating costs over the 20 years.

This illustrates why we use the collective present value of all relevant future cost flows as our measure of cost in the model. The model is designed to minimize that collective present value.

Freight costs and distribution problems. As in the problem of scheduling and controlling use and movement of prime metal resources, freight is an important cost factor and is highly sensitive to the decision of which sites to expand. In order to evaluate a potential expansion configuration we must first determine the freight costs for that configuration, and that can only be done by working out the best possible distribution pattern for both alumina and metal flows. As in the previous model, this fits a linear program-

ming formulation. There are a number of supply points, each with a given number of units *available*, serving a number of demand points, each with a given number of units *required*. There is a freight cost associated with the route from any supply point to any demand point, and the problem is to pick the routes so as to satisfy the demands at the lowest total freight costs. There is a distribution problem of this sort for the shipment of alumina to reduction plants, and there is a corresponding problem for the shipment of aluminum from reduction plants to customers and fabricating plants. Furthermore, the supply and demand points and their associated routes change each time we consider an *alternative* expansion configuration. You soon see why this problem has to be solved with a computer-based mathematical model.

Planning long-term economies for anticipated growth. There is more involved here than the application of distribution-optimizing techniques to each alumina-reduction expansion plan. We must also plan our future expansion moves so as to achieve long-term economies in light of anticipated growth. Suppose we have three potential reduction expansion sites, *A*, *B*, *C*, with a total existing capacity of 400 units, but a forecasted demand of 500 units distributed among the demand units. Thus we have a supply deficiency of 100 units. Suppose that this is the annual output of one pot line, so that all of the increase must be concentrated at one of the three sites. Suppose also that all other costs are equal for all the sites; so the entire decision on where to expand rests on the distribution costs.

The analysis is quite simple. We first assume that *A* is expanded by 100 units, then optimize the metal distribution under that assumption and compute the freight costs. We then assume *B* is expanded by 100 units and repeat the analysis, and finally we repeat the process for site *C*. The optimum distribution patterns and their resulting costs in this case indicate that our best decision is to expand *B*.

Suppose we do expand *B*. Three years pass, and during that time demand grows by 20 percent with the result that we are once again confronted with a 100-unit deficit. We repeat the

analysis we went through before. This time, we find that our best solution is to expand site *A* by 100 units. Obviously, we have made our expansion decisions so as to minimize costs. Or have we?

Suppose that, at the outset, we could foresee the market growth and therefore could have anticipated the second expansion requirement. Would we have changed our analysis? The answer is, "Yes, we certainly would." At the outset we would no longer simply review the three alternatives, expand *A*, or *B*, or *C*. There would be more alternatives to consider.

One alternative would be to expand *A* now and *A* later, or *A* and then *B*, or *A* and then *C*, or *B* and then *C*, and so on. There are now *nine* alternatives to consider instead of three, and we must apply the distribution optimization procedure nine times to get the best results.

Could such an analysis improve our decision? It most certainly could. In the case we have just gone through, the best decision is not to expand *B* and then *A*, as we just did, but rather *C* and then *A*. Under our previous plan, in which we expanded one step at a time as each requirement warranted, we did well the first three years. But under the second approach, in which we anticipated growth and thought in terms of a two-stage expansion, we did not get locked into *B* and were able to save \$130 per year from the fourth year on. The \$50 yearly penalty suffered by the least-cost plan during the first three years is a short-term distribution imbalance which is more than made up by future long-term economies. We can characterize the lesson of this example as trading short-term distribution imbalances for long-term economies, and that is an additional complexity of the expansion decision.

There is a second reason why future expansion must be anticipated. It has to do with what we have termed "site entry costs," meaning the present value of all the expenditures for establishing operations in a new site. These include capital costs for roads, power lines, wharves, and administration buildings, as well as the present value of certain continuous cash flows, such as fixed overhead and fixed power costs, if any.

The analysis for trading site entry costs

against cost savings is not too difficult. This is simply a go or no-go situation. We first assume the site is entered and compute the present value of all the resulting cash flows, including the site entry cash flows. Then we compare this with the lowest present value that could be achieved if the site were not entered. This has been done for the earlier example of sites *A*, *B*, and *C* and demands 1, 2, 3, and 4, with an assumed site entry cost of \$1,000 for site *B*, which was, as you recall, the potential new site. Following the application of the distribution optimization technique explained earlier, we find a lower present value of future costs if we do not enter site *B*, and conclude that this is our best alternative.

However, we now have learned our lesson and are on the alert for future growth in expansion requirements. This time we forecast growth requirements carefully and plan for future expansion in six phases corresponding to the requirements expansion. First, we assume that site *B* was not entered, and determine the best six-phase expansion program under that assumption. Then we assume that site *B* is entered, and find the best six-phase expansion program under that assumption. Since the present worth of future costs is less under the second alternative, we conclude that our best action is to enter site *B* right away, following with site *C*, further expansion at *B*, and so on. Correct?

No. Once again we are wrong, and for the same reason. We did not look at a wide enough range of alternatives. In this instance we should have considered the alternative of entering site *B*, but at a later date. Investigation of an expansion program involving an entry into *B* in year four and an entry into *B* in year six shows that if we delay our entry into site *B* until the fourth year, we get the lowest cost expansion plan. This example illustrates that future expansion requirements, and alternatives for filling them, must be anticipated to trade site entry costs for future cost savings and to trade the loss of immediate operating savings for deferment of capital expenditure.

How does this simple example relate to our real decision? We do not have only *one* site that is open for entry in every phase of a multiphase

expansion plan; we have several. Since we want to think of a ten-phase expansion plan, we have literally thousands of combinations of when and where to expand existing capacities. Once again, we see the need for a computer-based mathematical model.

All three of these considerations and the examples given have a common theme: future expansions must be anticipated. The expansion alternatives are no longer what do we do in the immediate future, but what is the best multi-phase expansion alternative. Another way of putting this is to say that the time dimension must be introduced. When we do introduce the time dimension, we greatly increase the number of possible expansion combinations; and, for each of these, both alumina and metal distribution patterns must be optimally adjusted for each phase of each expansion combination.

We can increase our metals output in a given year by expanding or entering any one of seven production sites, and these sites in turn can be supplied with their alumina requirements by any one of five existing or potential new alumina sites. The number of choices is somewhat limited by the fact that two of the sites have both alumina and reduction capabilities; so an expansion in reduction capacity at either of these two sites would call for an expansion in alumina at those sites also. Therefore, the number of expansion possibilities that year is 17. In effect, we can pick for expansion the two sites represented by any one of the 17 possibilities in the first year. We also have that same number of choices in the second year, so that for a two-year period we have 17 times 17, or 289 possible combinations. Now, if we extend this out for ten years, you can see what happens. Seventeen to the tenth power is two trillion possible expansion plans to be considered; and for each of these we must determine an optimum distribution pattern, both for alumina and aluminum.

Many of these alternatives are obviously undesirable, but still the number that must be considered, if we truly want to find the least-cost expansion plan, is astronomical. At least, it is

obvious that facility expansion planning cannot be done on the back of an envelope. A technique that provides an efficient equivalent to an exhaustive analysis of all possible expansion combinations is required.

Mathematical programming provides that technique. It systematically considers all relevant alternatives; it assures that none are overlooked; and finally it provides a bonus—a mechanical means for reanalysis to consider the effect of any change in the basic information, or to measure the sensitivity of the optimum expansion program to changes in data on sales forecasts, operating or site entry costs, tariffs, or taxes. The mathematical model and its associated computing algorithm impose a discipline which forces you to keep your data in neat, tabular forms and enables you quickly to change entries to these tables, repunch data cards, and run again with a new set of assumptions.

Finally, for the benefit of the more technically inclined, I will say a brief word about the mathematical model itself. We introduce a set of variables of the form, $X_{1, 3, 6, 9}$, which denotes the amount of metal supplied to demand region one by reduction location three, obtaining alumina from alumina facility six in the ninth year. Then we can write one equation that expresses the present value of all future costs as linear functions of these variables. We also write restraining equations in terms of these variables. One set of equations requires that the metal supplied to a given demand point in each year be equal to the amount of demand at that point that year. Another set of equations requires that the capacity used at any one location in any year be never more than the capacity *available* at that point during that year. Finally, there are equations to assure that the expansion at a given new site never occurs until after the model—in effect—pays the cost penalty for entering that site. We feed all these equations into a computer program that finds those values of the variables that will produce a minimum in the equation for present worth of future costs, while at the same time staying within the limits of the restraining equations.

INFORMATION SYSTEMS FOR BETTER MANAGEMENT OF MANPOWER RESOURCES •

ALLAN V. TULK

THE DOW CHEMICAL COMPANY HAS SET UP AN EDP task force to aid in the planning, designing, and creating of a single-entry, multiple-outlet, business information system. Dow wants such a system for a number of reasons, one of which is to improve its ability to match an individual employee to an individual job assignment.

A man's job has significance and importance to him: it determines his standard and style of living; it shapes his planning for the future; and, if he is in the right job, it increases his chances for personal satisfaction along with material reward. A man's job is also significant and important to his employer, for it represents an investment as well as a potential source of profit. Part of that investment is in dollars, but the far more vital factor is the investment in the human resource represented by the individual assigned to the job. If a person is in the right job, he sees a challenge, responds by growing in intellect and mastery of the task, and effectively produces the desired results. Thus both employee and employer benefit by sound matching of an individual and a job. This business of placement, of assigning a specific individual to a specific task, is generally termed "the selection process."

Throughout industry today, two broad changes are occurring with regard to jobs. The first is the gradual disappearance of certain types and styles of jobs. The second is the rapid introduction of brand new jobs—jobs nobody dreamed of even five years ago. These trends force managers to ask themselves (1) where they can best use the resources represented by veteran employees whose jobs no longer exist; and (2) where in the organization are the employees with the background to successfully fill the new jobs.

Just how do most people arrive at their present jobs? They may arrive at their positions or lines of work by plan and design. Early in life such a person may develop a particular skill or demonstrate a particular interest. Chances are that counseling at home or at school encourages his interest in that skill, and points him toward a particular field. After such a person undergoes formal specialized education, he begins a career that, to a great extent, he has anticipated. Others travel a different route. For one reason or another, they gain exposure in a variety of fields. They may change college majors once, twice, or even three times before attaining a degree. Their work records show a similar series of changes to jobs of different types and with varying levels of success. Modern corporations need people of both types. Complex technology creates a continuing demand for specialists highly trained in a particular field. At the same time there is evident need for individuals with sufficient background and flexibility to adapt to and adequately discharge the duties of those jobs still to be developed.

These trends create management decision-making problems. There is often some difficulty in picking the right man to fill a long-existing and standardized job. And picking the right man for a job that never before existed is considerably more of a problem. Almost invariably these needs force modern management to decide whether to go outside the organization for new employees or to search within the organization for people who can be retrained to fill the new

ALLAN V. TULK is Employee Information Coordinator, Corporate Industrial Relations, The Dow Chemical Company, Midland, Michigan.

jobs. Most companies prefer to retrain available employees. This preference puts the selection process squarely in the picture, for now the manager must identify specific individuals who should be considered. He may know what qualifications and experience he intends to use as a criteria, but where can he look to discover who has these qualifications and experience?

The obvious answer is the personnel file; but, like most obvious answers, this one has its weaknesses. I will cite just two of the current weaknesses in this system at Dow. First, the Dow manager simply can't afford the time to search through the 33,000 personnel files for the one best man, or even several good candidates, for a given job. Even if he could discard whole groups because of a requirement such as a chemical engineering degree, the manager still would be faced with literally hundreds of files. Second, and most pertinent to the electronic data processing system and profession, is the character of the personnel file. When the intention is to foresee and prepare for the future informational needs of management decisions, few areas are more difficult to define and properly design than the personnel file. Selection in too many cases becomes more a game of grab bag than a studied process. A manager, his staff, and somebody from the personnel department get together. They scratch their heads and try to decide who among those available have the right qualifications. They produce a list of names. Then a quick check of various personnel folders is made; background information is scanned; a round of interviews is begun; and a judgment is made either to begin again or to make a job offer to a particular person. In either case the odds against choosing the right man are overwhelming, and a number of well-qualified candidates may not have been considered. The larger the organization, the larger the number of qualified candidates likely to be overlooked.

This grab-bag method gives little assurance that any job is being filled by the best available candidate. Sooner or later those qualified individuals who have been overlooked are likely to lose their drive and desire to perform for the company and lapse into indifferent performance. Or they may retain their ambition but take it,

along with their qualifications, to another employer. Neither result benefits the company that overlooked their potential.

Such considerations of the selection process caused the initiation of a study by Dow to determine what information Dow really had on its 33,000 employees. The company's complexity makes the selection process as we know it a difficult one, but at the time of the study Dow's plans for the future demanded effective improvement in selection capability. To get a good cross section of the company, some 40 departments, functions, and areas of work were surveyed. The key questions asked about personnel data were these:

1. What information are you currently receiving to help you run your business?
2. Is that information prepared by machine or manually?
3. What information do you really need to run your business?
4. What information needs do you see for the future?

The responses to the third question produced rather interesting reading. Generally speaking, the managers surveyed felt that the data available to them were good. Some were concerned that the data weren't available fast enough or often enough, but most indicated that they were content or would be if they could have "just one more report." And they were fairly specific as to what that report should be. The two most wanted personnel reports were a new skills inventory and an improved record of performance appraisal.

Indeed, such reports would be vital in a good selection process. The skills inventory would provide information on qualifications. The personnel appraisal or performance review would answer the question of how well a man has performed in his various job assignments. It is significant that so many managers expressed a need for such information. Even more significant is the fact that most of the data for a skills inventory and a personnel appraisal record were already available. This fact was discovered in the answers to the first two survey questions, which were tabulated into two groups—data processing reports and manually prepared re-

ports. Each report was keypunched for the various data elements it contained, and two matrixes were constructed. The volume of duplication was staggering; for instance, it was discovered that Dow data processing units were producing more than 200 different personnel reports a year. Many of these reports were being produced monthly—some even oftener. In addition, these 200 reports showed over 700 different items of information being gathered on many employees. The general scope of the data is indicated by the list of groups then responsible for the majority of the reports studied: personnel, payroll, technical placement, college recruiting, salary administration, medical, and safety departments.

The next step was an analysis of the information needs spelled out by the managers surveyed, using the answers to the third and fourth questions. The survey results showed that we were recording and gathering much if not all the information we would expect to be useful in the selection process. But we could only guess how much of it was being used. The manner of gathering and processing convinced us that much available information was never even considered. There was evidence that people needing specific available information did not know the information existed or, if they did, simply could not afford the time required to locate it.

The skills inventory situation is a prime example. Dow, like many other companies, had kept records on skills of its employees for some time. Most such records center around some form of an educational achievement catalog which is kept more or less up to date. At the time of the study the information available on most of Dow's professional and technical employees included the employee's work history at Dow, language skill other than English, education attainment, work history prior to Dow employment, foreign work experience, technical and professional specializations, and special training qualifications. Along with this was reported general information which Dow gathers on all employees, such as name, sex, birth date, hire date, and social security number. What was done with this information? Some of it—but not much—was published. Much of it could not be retrieved by machine methods. Most often, these

data went into the personnel folder of the employee. It was likely to come to light only when and if that folder was selected for review because someone remembered that that man had some prior background that was desirable for another job.

These findings indicated a need for a better skills inventory. Certainly Dow needed a way to systematize the recording of skills data. More important than anything else, an effective way to retrieve skills data for use in selection had to be developed.

Much the same was true for performance appraisal information. Again, like many other companies, Dow has been collecting such data in one form or another for some years. A variety of appraisal techniques has been used, and each has seemed to offer some advantage. The task force was not primarily concerned with the technique of performance appraisals. Interest lay mainly in recording the information for future availability, in determining a reasonable retention period for the information, and in devising a method for retrieving the information for use.

Priority went to the preparation of a new skills inventory based on electronic data processing methods. For each exempt Dow employee we have gathered everything he wants to tell us about his skills background. Along with other information available in Dow records, the data on each exempt employee have been machine-recorded. During January 1966 we ran our first print-out from the machine. One part of the print-out was an individual copy of each employee's inventory entries. These were distributed to the individuals for correction and updating. In the future, another part of the print-out will be a series of separate catalogs of key factors in the total qualifications list. These catalogs will go to managers of major divisions and functions and will be of great importance in selection decisions. As new or revised skills data come in, they will be entered into the system. By one entry operation, any one data element will become available for all future print-outs. When a complete updating of the catalogs is indicated, the up-to-date information is thus available for print-out. And, should a search of the catalog fail to produce the desired

information, the capability exists to search by machine for the latest data.

Dow's information on performance appraisal is also scheduled for electronic handling. With the skills inventory as a beginning, the addition of performance appraisal information to the total file will not be a major task. In approaching this problem, we plan to accumulate a minimum of four years of appraisal data on all salaried employees. A manager who looks at this much appraisal data on an employee should have a reliable reference for whatever action he takes. At the very least, he need not rely on his memory or someone else's as the sole record of how a man has performed in the past.

Certainly the matching of individuals to jobs is an exacting chore. It is equally certain that important decisions involving people and their past performance are often based on a fraction of the available information. The results of such decisions can be just as binding as any sentence handed down by a judge. But who among us approves of a judge passing sentence with something less than all the evidence, or at least all the available evidence?

Dow doesn't claim that its new system of skills inventory and the performance appraisal records are perfect, but these do provide a more effective and immensely more available base of information. We don't expect computers to make our work on the selection process any less exacting, but it should become easier. We know we will have to make some changes in our procedures. Job descriptions, for example, must be put into terms that computers can handle. Generally speaking, this can be accomplished with minor modifications in existing job write-ups. Similar modifications will be needed in other areas.

The matching of skills to the qualifications descriptions could become a major task, even with machine methods, depending on how far we expect the machine to carry the matching step. Our general view is that the computer should be relied on for preliminary matching but not the actual selection of a specific job, for some aspects of selection will always require the human element. The way a man speaks, the way he dresses, and the way he listens are among

the attributes that may be important in a specific selection. So the most we expect from the machine is a rough screening of the available work force to identify available, eligible candidates. Using the computer for this screening offers definite advantages to the manager who must make the actual choice. First, it minimizes the possibility that a qualified candidate will be overlooked. Second, by speeding up the preliminary screening, it increases the time available for making the final choice.

Thus, because of the electronic data processing techniques, Dow expects to gain a better grasp of pertinent personnel information. We plan to use these techniques to produce the two specific personnel information reports for which Dow managers indicated they have a pressing need. Above all, we anticipate that EDP will enable us to do a more effective job in the selection process to match individuals to job openings in a way that will most benefit both the individuals concerned and the company.

Projects such as the one at Dow outlined above contribute to the progress of business as a whole. These projects cannot succeed alone, however; concomitant advances in electronic data processing are necessary to make the projects feasible. The users of EDP systems for personnel records have specific needs to be filled over the next few years. Our principal desires are these: We want a software-hardware package that will allow us to receive, store, process, and retrieve data with minimum programming effort. Too, we want greater flexibility in our system to meet the changing information needs of management, at the same time avoiding long delays any time a major program has to be redone.

What are we asking for specifically? To begin with, we want a new language that is completely user-oriented. This language must be designed for and geared to the needs of the user. It should be uncomplicated, easy to learn, easy to use. The language should avoid the vocabulary of the computer specialist in favor of the vocabulary of the managers in accounting, personnel, production control, and similar areas. It must be structured to allow such users to retrieve, manipulate, and display the information

they desire. The language must be dynamic rather than static, and it must have the ability to grow and be adapted to meet the ever changing needs of its management users.

Once we agree that a new language can be written, we can start thinking about the data base. Each element in the data base should be made up of a group of characters that cannot be divided further and still have independent meaning. A dictionary must be provided which shows each data element and its specific definition. This system should be so designed that new data can be entered into and extracted from the data base by use of the new language. And our users—by means of data elements, numbers, or some other device provided by the data processing professionals—should be able to retrieve a single data element, a complete record, or a collection of files simply by feeding an appropriate language statement into the computer.

The filing system for the data base must also be user-oriented. It should be designed to facilitate storage and retrieval of large blocks of data. We want our users to be able to do this without having to develop an extensive knowledge of the file organization used in the system.

There must be a control device for the data base. Obviously, personnel records of any scope contain certain material of a sensitive nature. Therefore the system should include security passwords which the data processing group would assign to users' departments so that confidential elements would be available only to persons holding the security password.

Another goal in the design of the system is efficient utilization of the equipment. However, the most important goal is the creation of a man-machine interface that makes retrieval of information easy and fast. The word "fast" represents the first mention of the time factor for the system. "Real time" in this system will be defined to mean the time period which the user establishes as the limit within which the response to his inquiry must be received if the information is to have any value. The total of real time effectively utilized will have a direct bearing on the user-cost of the system.

Is the described system within the practical limits of the state of the art? The management

of The Dow Chemical Company thinks it is. So do the development people of the equipment manufacturers. Dow has contracted to develop, build, and install a new EDP package. The programming and filing systems I have described are part of the package covered by this contract. Our plans are to have this system operational within Dow sometime in 1967.

As we put this system into service, we will be working toward a specific and ambitious corporate objective: EDP handling of our personnel information systems. We want to put Dow's personnel information into a single EDP data base and then use EDP to keep it up to date and readily available for widespread use when and where it is needed. Our objective carries the hardest requirements that any business proposal must face—that is, the benefit must justify the cost. In all our planning, we work with the full recognition that how close we get to our objective of a total personnel information system will depend directly on the benefit-cost relationship. And on this benefit-cost point, the real-time factor will probably dominate. This relates to the various available methods of data storage; of these, storage that provides constant, instant availability is more costly. Thus, if every real-time demand proves to be "right now," the system costs will go up—and the benefits will have to be greater to justify that rise.

Assuming that most criteria are satisfied, what do we visualize as the scope of our total personnel information system? Our use plan is a broad one: The goal is to provide on-line availability to users at all Dow locations throughout the United States. By remote-input devices such as teletype, each Dow location would become a direct contributor to the data base. The contributions would include new entries for new employees or new data to be recorded as well as updated information to keep the data base current. By the use of output devices such as cathode ray tubes, each location could be a direct user of this system, extracting and displaying any data for which the particular location or operation has been provided the access control codes.

You may question the practicality of the system requirements outlined. Perhaps such a

system demands too much from electronic data processing as an aid to managers who must make the most of their available manpower resources. But consider this observation that resulted from my work on the project described. Manpower always has been and always will be the most precious resource of any society, nation, or corporation. Today, managers complain that manpower is becoming their most expensive resource. The truth is that manpower is expensive only when it is misused.

Better EDP systems and better methods for utilizing such systems can and will enable busi-

ness and industry to improve its management of human resources. Obviously, business and industry would benefit by this. But more important, the society served by business and industry stands to be better served when its most valuable resource is more effectively applied.

And of utmost importance, the individual himself will benefit. For when he finds the task that presents the challenge that stirs fullest development of his capabilities, he makes his greatest contribution and attains the fullest reward of satisfaction and achievement of his own potential.